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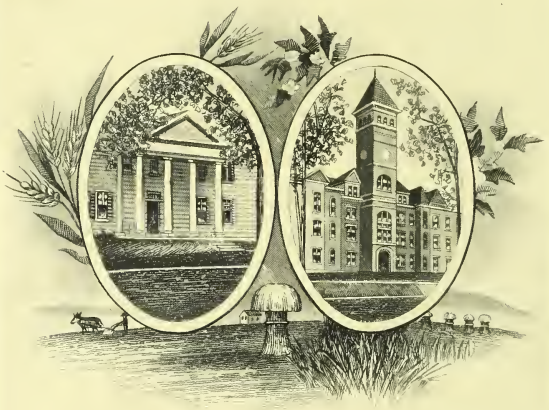

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DEPARTMENT OF THE INTERIOR
FRANKLIN K. LANE, Secretary

UNITED STATES GEOLOGICAL SURVEY
GEORGE OTIS SMITH, Director

MINERAL RESOURCES

OF THE

UNITED STATES

1915

H. D. McCASKEY
Geologist in Charge, Division of Mineral Resources

PART I—METALS

H. D. McCASKEY, Geologist in Charge

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MINERAL RESOURCES OF THE UNITED STATES FOR 1915—PART I.

THE PUBLIC INTEREST IN MINERAL RESOURCES.[1]

By George Otis Smith.

A nation's mineral wealth may benefit its citizen body in two ways—as a source of direct revenue to the State and as a basis of industrial development. The task of placing the true social values upon mineral resources therefore involves the determining of the extent to which these two methods of serving the public interest are in harmony, and, if they chance to be opposed, then the weighing of the alternative benefits.

Mineral wealth as an expendable resource rightfully commands the attention of the patriotic citizen, whether he be lawmaker or landowner, geologist or chemist, capitalist or mine worker. Wise use becomes a duty when anything can be used only once; and if full utilization means much to society, individual rights whose exercise involves anything less than full utilization must be subordinated to the public interest. In a democracy, therefore, the use of a mining property should serve the many, not the few. Thus, the development of mineral resources is of nation-wide value and the promotion of their best use properly becomes a national duty.

A nation's store of mineral deposits is a national asset whose value can not easily be overestimated. In his recent report to the President the Secretary of the Interior, in speaking of the assets of this country, gave the mineral resources first rank under the suggestive title "The foundations of power." The higher the stage of civilization a nation may attain the more exact becomes this conception that mineral wealth is the foundation of power. It is not without striking significance that mineral names have been given to the steps in the evolution of society—the stone age, the copper age, the bronze age, the iron age, and finally the age of coal, in which we of this twentieth century live. And the dependence of society upon these mineral products is shown by the fact that never has the per capita consumption been greater, not only of coal, but also of iron and copper, and even of stone.

A nation that produces under normal conditions 40 per cent of the world's coal and 66 per cent of its petroleum surely has its share of the two great fuels; add the fact that our mines, furnaces, and

[1] Delivered before the Second Pan-American Scientific Congress, Washington, Jan. 3, 1916.

smelters yield 40 per cent of the world's iron, 60 per cent of its copper, and 32 per cent of its lead and zinc, and the reason is patent for America's industrial greatness.

Independence through possession of the material resources essential to modern life is itself a promise of a nation's integrity, and the nation that makes the whole world its debtor through shipments of the mineral fuels and the metals and the mineral fertilizers occupies a strategic position in the construction of international policy.

How best to realize upon this national asset is a problem in democratic government. Under Roman law and in part under early English law, as well as under most continental and Spanish-American systems, the ownership of mineral deposits was subject to certain rights of the sovereign.[1] This "regalian right" had a common origin with the broader and more modern theory, stated by Gen. Halleck in 1860, that mines "are by nature public property and that they are to be used and regulated in such a way as to conduce most to the general interest of society."[2]

This regalian doctrine has been followed by only a few of our States, and indeed it can be said that practically all that remains of this old doctrine in our present mining system is the common term "royalty," now used mostly, however, for the tax on output paid to the private owner. As a source of direct governmental revenue mineral deposits have been treated much as other property, on the principle that taxation shall be equal. In the recent discussions of this practical civic problem there stand out a few generalizations that perhaps present the difficulties of the problem rather than its solution. An equitable valuation of undeveloped ore deposits is hardly to be expected, and either a high valuation or a high rate of taxation must tend to hasten the exhaustion of a mine, resulting in overproduction and in the early termination of opportunity for the mine worker. At best, both theory and method in the appraisal of mining property involve the determination of the present worth of expected profits. After estimating probable tonnage of ore developed and prospective, forecasting reasonable future costs, and averaging fluctuating prices, as well as giving due consideration to the rate of mining as possibly affected by market and other conditions, the public officer charged with making an ad valorem appraisal completes his task by applying a factor of safety as evidence of good faith.

Opposed to this method of appraisal based upon expected future returns is the system of taxing the actual present output. Aside from the greater certainty of this method, the tax on output possesses an added advantage in that it provides revenue for local governmental purposes at the time when the demands are heaviest and in an amount roughly proportioned to those demands. However, either a tax or a royalty that is based upon the gross value of the output falls short of the ideal by its lack of consideration of the important element of cost, which may vary less than the unit value of the output, with the result that the tax rate which is excessive for a $5 ore is actually far less burdensome on a $50 ore, although the amount of this tax is ten times as large.

More equitable than even a graded tax upon gross output is one assessed upon net returns. All that the public can logically ask

[1] Lindley on Mines, vol. 1, p. 21.
[2] Quoted by Lindley, op. cit.

on account of the development of mineral resources is a share in the profits. If in the operation of a mine the margin between costs and returns is small or nothing, why should society exact its pound of flesh? On the other hand, the regular dividend-paying company can well afford to recognize the general public as a silent partner possessing a share in the profits of the business. Prof. Seligman[1] believes that "the main reason why the twentieth century has become the century of income taxes rather than of property taxes" is the feeling on the part of business men that yield or income is the more satisfactory index of fiscal obligation.

It is as the basis of a nation's industrial growth, however, that mineral resources loom largest. Both self-centered independence and world-wide participation in commerce must come through the fullest use of these basal materials. Consumption of the essential minerals does not place a nation in the spendthrift class, but is in fact a measure of its industrial efficiency. It has been pointed out that the greater per capita consumption of coal in the United States than in any other country proves that this nation is burning coal for other nations—it is the gratifying test of industrial capacity. By this measure too, Mr. Finlay[2] contends that "the industrial output per man is greater in the United States than in any other country."

The development of the United States in industries other than agriculture is well illustrated in the story of the utilization of our mineral resources. Though such agricultural products as cotton and the cereals continue to bulk large in the trans-Atlantic trade the mineral products form a constantly increasing share of this country's contribution to the world's needs, and there is evidence that under the present abnormal conditions our mineral exports are winning for the United States of America a new and larger place in the world market.

In the third of a century just past the exports of foodstuffs, while showing an actual increase in amount, have fallen from 55 to 21 per cent of the total exports, and there has been a corresponding gain in the export of manufactures from 24 to 58 per cent. Again, by comparing the exports of 1880 with those of 1913, the latest year unaffected by abnormal conditions, it is found that the value of exports of mineral products and manufactures thereof has increased from less than 4 per cent to 42 per cent of the total exports, an increase amounting to more than one and one-half billion dollars.

The epoch of rapid growth of the mineral industry in the United States began about 35 years ago, and this third of a century has witnessed wonderful development. Clarence King, in the first administrative report of the United States Geological Survey, analyzed the situation in 1879 in these words: "We are yet at the very threshold of the industrial life of the Republic," and, looking forward, he added: "The mineral industries will soon reach an annual yield of a thousand million dollars of value." May I now remind you that five times already our country's annual mineral production has exceeded two thousand millions of dollars.

For this period of development since 1880 statistics of the mineral production are available, so that the extent of the expansion of the industry can be summed up in the statement that the value of the

[1] Seligman, E. R. A., Am. Acad. Polit. and Social Sci. Annals, March, 1915, p. 3.
[2] Finlay, J. R., Min. and Met. Soc. America Bull., vol. 8, p. 151, 1915.

output has increased nearly sevenfold, while our population has less than doubled. If we compare directly the output per capita of population the record of increase in the output of the more important mineral products becomes really instructive or even inspiring. Thus, in this period of 33 years the production and consumption of coal per capita has increased from less than 1½ tons to nearly 6 tons—an increase of 357 per cent. Similarly the per capita production of iron ore increased 337 per cent; petroleum, 391 per cent; copper, 1,200 per cent; cement, 2,087 per cent. Gold and silver increased only 23 and 22 per cent, respectively, but lead increased 125 per cent and zinc 638 per cent. This is a record of which mining men of this generation may be proud.

If statistics for the more important agricultural products are studied in a similar manner it is found that the total increase during the same period has not much more than equaled the growth in population. This is true of the two leading grains, corn and wheat, the one having somewhat more than doubled and the other not quite doubled in the third of a century, so that the production per capita shows only a small percentage of increase. In cotton the gross increase has been larger, approaching 130 per cent, but wool has failed to increase as rapidly as the population. It is only sugar that shows an increase, both in domestic production and in consumption, at all comparable with that of most of the minerals mentioned, the per capita increase being 394 per cent, or about the same as that in the other carbon compounds, coal and petroleum.

Especially notable in this period of phenomenally rapid strides has been the industrial development of the new South, which has more than kept pace with the country as a whole. In 1882 the Southern States produced only 8 per cent of the mineral output of the country; in 1890, 14 per cent; in 1900, 16 per cent; in 1910, 19 per cent; and in 1914 their output was 22 per cent of the total mineral production. Thus the South, with steady gains, has been utilizing that share of industrial opportunity afforded by its varied wealth of mineral.

Dr. Chance [1] lately remarked that what is sometimes called engineering efficiency is "more broadly described by the term 'conservation of labor,'" and so in any discussion of the national significance of advances in engineering it is important to realize that the object of the engineering sciences is simply to win the largest results with the least possible expenditure of labor. If a poet ever seeks a theme in the story of the mines he should write the epic of this struggle of man with mountain masses, where victory comes only through the harnessing of Titan power. To-day huge steam shovels mine iron and copper and coal and giant electric dredges win the gold from gravels that are too poor to work by less efficient methods.

Thus it follows that the most gratifying phase of this mining development is the marked increase in man's productive capacity. Let us take the 20-year period 1889–1909 and analyze the coal-mining record. Roughly stated, the number of mine workers has a little more than doubled in that period, the output of coal has more than trebled, and the capital investment has more nearly quadrupled. The exact percentages of increase are 123 per cent in

[1] Chance, H. M., address at Pennsylvania State College, Nov. 5, 1915.

employees, 226 per cent in production, 252 per cent in capital. Stated in terms of efficiency, the mine worker increased his individual output from 471 to 691 tons a year, while the average annual output per dollar of capital remained nearly the same, about two-fifths of a ton, the increase in capitalization per ton of output being less than 8 per cent.

In iron mining the record for the same period is even more striking; the number of miners increased less than one-half, the capitalization nearly trebled, and the output nearly quadrupled. In the iron mines, then, both labor and capital became more efficient, the output per miner increasing from 385 to 995 tons and the production per dollar of capital from one-seventh to one-sixth of a ton; and this improvement did not halt with the census year of 1909. All this tells the story of steadily increasing efficiency of mine worker, mine equipment, and mining methods—that is, of the contributions by labor, capital, and engineering.

The human aspect of this picture of change in the mining industry is full of encouragement to every one interested in the welfare of his fellow citizens. That type of industry is to be desired which employs a maximum of skilled labor and a minimum of "muckers." The labor of any country is most benefited by the export of finished products rather than of crude ore and by the import of raw materials rather than of manufactures. Looking at the question from the standpoint of the United States, it is the product of American labor rather than the bounty of our natural resources that should go into the world's markets, for betterment of industrial conditions can come best through expansion of manufacturing. The increase in the element of labor in the product exported will mean that we are not bartering away our heritage of natural resources, but rather that we are using these resources as a basis simply for the expenditure of labor, which renews itself.

Confidence in the future of the mineral industry may be strengthened by even a passing glance at its increasing diversity. The statistics of mineral production in the United States in 1880 covered 51 mineral products, whereas the table of production for 1914 contains no less than 95 items, and the accompanying report mentions 89 other minor products. Since 1880 the baser metals have come to the front, and indeed the nonmetals, once of subordinate rank, now exceed in total value the metals. Moreover, the small increase in the output of gold and silver has been made in part with both these noble metals in the rôle of by-products from copper and lead mines.

The subject of by-products stimulates inspiring thought. Under the exceptional demands of the year just past sulphuric acid, which has been a source of embarrassment to the smelter operator, has become a commodity of great price. Dr. Douglas, indeed, in observing the advances in blast-furnace operation, once raised the question whether eventually pig iron will be "the principal object of manufacture or one of the by-products." In the case of that highly useful metal platinum—of which the United States, unfortunately, has an insufficient supply—the amount won in the refining of gold bullion and copper matte of domestic origin is fourfold the small quantity obtained from our platinum ores and concentrates. The metals selenium and tellurium are produced in the electrolytic refining of

copper or may be saved from smelter fumes, and if uses are found for these metals considerable demand can be met by the supply from these sources.[1] Gallium, hitherto hardly more than a curiosity among metals, is now recovered as a by-product in zinc redistillation in quantities sufficient for a real test of its possible uses.

Along with all this marvelous increase in material production, it is gratifying to note again that most of the development has been of the type that betters the conditions of living. During the period of marked growth, metal mining, for instance, has passed from the exploitation of bonanzas to the working of low-grade deposits, a change which, as Dr. Raymond has remarked, by creating larger and more permanent communities has laid safe foundations of civilization and progress. Thus does the utilization of our mineral resources measure up to the higher standard of public service by building homes and giving all the workers a better opportunity to live a full life. This is the ideal of democracy.

The relation of mining to other industries deserves a passing word. Speaking of the era of mineral exploration that began with the finding of gold in California and Australia, Mr. Rickard[2] has termed that discovery, "the prelude to a world-wide migration, an enormous expansion of trade, a tremendous advance in the arts of life, and the spread of industry to the waste places of the earth." The miner has ever been the pioneer of civilization. The history of the winning of our own West has been in large measure the story of the rancher that followed the miner, and the railroad builder that followed both. This vital interrelation between mining and agriculture and transportation continues to this day.

Both the past record and the present status of the mining industry show that the mineral resources of the United States possess largest public value in their indirect contribution to national development. Even in the case of certain mineral deposits in public ownership the substitution of a leasehold system for the other form of mineral-land tenure may better be sought for the purpose of insuring development and beneficial control of operation than with an eye single to the amount of royalty possible from production under the lease. In fact, it may be easily shown that the State or Nation will not be so much benefited through a direct royalty as through the indirect revenue gained by the establishment of a new industry, and by its influence on the neighboring agricultural areas and the transportation systems to which the new traffic is tributary. The value of the direct and indirect benefits can not easily be appraised and compared, for prosperity can not be weighed.

The difficulties as well as the inequalities that would attend the imposition of a tonnage tax or even a tax on gross proceeds may be illustrated from current mining statistics. The net proceeds per ton of ore produced in one mine may exceed the gross value per ton of the ore produced in another; and in still another mine with even richer ore, heavy costs may leave little margin of profit. Whatever the basis of the public's claim for revenue, the determination of a proper royalty presents great practical difficulties; yet, by imposing a fair tax on earnings, similar to the present corporation tax, the

[1] Hess, F. L., U. S. Geol. Survey Mineral Resources, 1914.
[2] Address at Columbia School of Mines, May 29, 1914.

desired results are secured. If taken in large units, the income from mining shows a fairly definite percentage on output. Thus in 1913 the dividends paid by metal mines in Utah[1] amounted to 5½ million dollars, or about one-eighth of the gross output. Or, taking a longer period, the aggregate dividends paid by mining companies of the Tintic district in Utah in about 40 years are estimated at 27½ million dollars, or more than one-sixth of the total production for that period.[2] Other districts might be cited where the dividends paid are at the rate of $3 or $6 or more per ton of ore mined, yet in equally successful mines the large dividends paid may represent only 50 cents per ton. However great may be the variation in earnings and losses as figured on the tonnage basis, the aggregate dividends distributed are large and represent on the average an appreciable fraction of the gross value of the output. And under existing laws these profits of mining pay tribute to the nation's need.

The importance of the income tax now paid by the mining corporations may be shown by the fact that under the market conditions of the year just past several of the largest copper companies will probably pay into the National Treasury something approaching a mill on every pound of copper sold, or perhaps $2 a ton. For this exceptional year the Federal corporation tax on copper mines alone may total a million dollars. In a State where net proceeds are taxed, not less than half a million dollars of State revenue is expected from two large mining companies.

Whether the mineral resources are in private or in public ownership, even a hasty consideration of the subject suggests the need of making a distinction between minerals in which the domestic and foreign competition is sharp and those in which the margin of profit is so large that the tax will neither affect the Nation's ability to compete in the world market nor increase the price to the domestic consumer. In short, the public's direct share of the proceeds from mineral resources must not be so great as to affect unfavorably labor's opportunity or capital's incentive.

Because of the essential relation between the mineral resources of a country and its prosperity, both national and international, there rests upon the public a continuing obligation to the mining industry. The modern doctrine of conservation was well expressed by Dr. Raymond [3] nearly 50 years ago in his first report on mineral resources:

> In view of these peculiar relations of mining, it is evident that governments are in a certain sense trustees of the wealth stored in the mineral deposits of their realms—trustees for succeeding generations of their own citizens and for the world at large. It is not a matter of indifference to the citizens of this country whether our mining fields be ravaged and exhausted in one or even five centuries, when they might last a score.

The governmental duty to the mining industry first of all is to promote use without waste. The educational and investigative work of the Government scientific bureaus is the Nation's contribution, and in this application of science to the promotion of the general welfare of the industry, the chemist and the engineer, the geologist and the metallurgist cooperate, and the large service rendered through

[1] Heikes, V. C., U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 374, 1914.
[2] Heikes, V. C., idem, p. 393.
[3] Raymond, R. W., Mineral resources of the States and Territories west of the Rocky Mountains for 1868, p. 176, 1869.

the collection and publication of scientific statistics of mineral production and of mine accidents has won from the industry deserved recognition. The Government aid extended to any industry may better take the form of real leadership in applied science than of ingenious schemes of artificial stimulation. W. R. Whitney[1] has accurately stated this relation: "Search for new knowledge is the insurance for the future of the industries."

Equally important, if not indeed altogether imperative at this time, is the need that the public support only such proposed legislation as may promise to encourage engineering efficiency in the mining industry. The public interest requires that the idea of the Government as a trustee be kept in mind, yet it is no less essential that the trustee fully appreciate just to what extent individual initiative and especially corporate effort are attaining some of the very ideals desired in the public interest. By its constructive effort the large unit in production—"big business," if you please—is winning such victories in the largest and wisest use of our mineral resources that its public-service nature is becoming apparent. Public regulation of private operation is the people's safeguard, but regulation need not be active as long as these great industrial units are seeking larger profits not by artificially curtailing production or raising prices but rather by eliminating waste and lowering costs. The larger dividends paid by mining companies to-day are won not so much through monopolistic control of virgin bonanzas as through the possession of tracts of mineral land big enough to warrant great expenditures of engineering skill. It is the day of large returns from lean ores. The net result of this type of exploitation is to increase rather than to decrease the Nation's resources. Even concerning an expendable resource it is in a sense true that "There is that scattereth and yet increaseth."

Seven years ago Prof. Lindgren, in discussing the visible reserves of copper ore in the United States, itemized the estimates for four districts in three States, for which he obtained a total of about 160 million tons of developed reserves, and his comment[2] was: "Each year will, however, surely find extensions of reserves added to those already discovered." Now, indeed, these four districts have known ore reserves amounting to over 600 million tons, not to mention 60 million tons already mined, mostly in these few years. Nor is this gratifying increase due alone to the exploratory work of the mining engineer. Since 1906 the average recovery from United States copper ores has decreased from 50 pounds of metal per ton to 32 pounds.[3] This change in quality of ores mined and treated is due more to the improvement of methods than to the exhaustion of the richer deposits. The continued lowering of the cost of mining and treating a ton of ore has made possible this reduction in the grade of ore that can be profitably handled, and the result is a corresponding increase in the copper ore reserves of the country. Thus do the engineers and metallurgists work together to place the copper industry upon a more lasting foundation, and with this constant improvement in mining methods and mill and smelter practice

[1] Am. Acad. Polit. and Soc. Sci. Annals, May, 1915, p. 94.
[2] Lindgren, Waldemar, Resources of the United States in gold, silver, copper, lead, and zinc: U. S. Geol. Survey Bull. 394, p. 142, 1909.
[3] Butler, B. S., U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 555, 1915.

nothing less than an annual inventory of the nation's mineral resources can keep the people truly informed.

The only increases in known mineral reserves comparable with that credited to the copper companies are the equally important changes in the estimates of this country's phosphate and coal reserves. The field work done by the United States Geological Survey during the last six years has increased the known reserves of phosphate rock in the publicly owned lands of the Western States from a few hundred million tons to more than 5 billion tons. As for coal, the quantity of easily accessible anthracite and bituminous coal exceeds the estimated tonnage in 1909 [1] by 440 billion tons, an increase of nearly 30 per cent. This change in Mr. Campbell's estimates is due almost wholly to the work done in the intervening few years under his direction by Government geologists in classifying and valuing public coal lands.

The day of large opportunity for both exploration and investigation of the mineral resources of this country is not past. In this time of adjustment to special demands it is easy to be optimistic regarding future advances along all the engineering lines leading to the full utilization of our mineral wealth.

The recognition of the extent to which modern civilization rests upon mining and the realization of the consequent need of promoting efficiency in mineral production will insure the placing of the proper estimate of value on the public interest in mineral resources. As the nation's future welfare depends on the continued productivity of our mines, it follows that even if the nation's mineral wealth does greatly exceed that of any other country the public interest requires that no part of it be squandered.

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[1] Campbell, M. R., Coal fields of the United States: U. S. Geol. Survey Bull. 394, p. 8, 1909.

MINERAL PRODUCTION OF THE UNITED STATES.

INTRODUCTION.

By H. D. McCaskey.

SCOPE OF REPORT.

The report on the mineral resources of the United States in 1915, from which the present summary of production is prepared, covers the thirty-fourth year for which published reports of the mineral resources division of the United States Geological Survey have been issued.

For details of the various domestic mineral industries in 1915 the reader should consult the chapters by subjects. These are gathered together in the two parts of the final report, Part I including the metallic subjects and Part II the nonmetallic. The individual chapters have been published in separate form as fast as they were completed, most of them long in advance of the volume, and the essential statistics and reviews were given out to the press even before the separates were ready for distribution. In fact, preliminary reviews and close estimates of production, imports, and exports, and other statistics for 1915, were given to the press within a few days after the close of that year. The volume therefore represents the final repository of the information for the year, but its appearance does not at all indicate the dates upon which the leading features of the component parts have been made available for use.

SPECIAL DEMANDS FOR INFORMATION.

The year 1915 was notable for the great strides in the mineral industries, and this exceptional activity was reflected by a greatly increased demand upon the United States Geological Survey for information and by increased difficulty in fully covering the rapid changes and developments in many of the industries. Much of the information required by the public at large, as well as by special workers, has been included in the various reports by fuller treatment or elaboration of previous data available; but almost as much has been given out by correspondence bearing upon special needs. All demands upon it have been met by the Survey without increase of available funds, but at the cost of considerable delay in final publication of the results and of other work in hand.

ACKNOWLEDGMENTS.

The United States Geological Survey is under obligation for reports from practically all domestic mineral producers, smelters, refiners, and mill men; from many manufacturers of mineral products; and to a very large degree also from operators of prospects, mines, quarries, and wells not producing but undergoing some development or

being merely held by assessment work. The total number of these correspondents whose operations have been obtained for 1915 was about 95,000. Not only by correspondence but also by conference in its offices and elsewhere and by the field work of its specialists the United States Geological Survey is in close touch with the mineral industries of the United States and the value of the reports, quantitative as well as qualitative, is therefore unique.

Thankful acknowledgment is also due the considerable number of Federal and State officials, bankers, merchants, transportation officials, and others, who have generously responded to requests for data required to complete the investigations.

ORGANIZATION.

The division of mineral resources of the United States Geological Survey, which is responsible for the annual reports "Mineral Resources of the United States," is divided into two sections—the "metals section," which prepares the reports of Part I, and the "nonmetals section," which prepares those of Part II, including fuels, structural and chemical materials (other than metal), and other nonmetallic products. Ernest F. Burchard is geologist in charge of the nonmetals section, and the writer is charged with the administrative supervision of the division, of the metals section, and of the western offices of the division.

These western offices were established primarily for the collection of data for the annual mines reports on the precious and base metals of the Western States, but they have been brought into such close touch with the mining industries across the country generally that they now cooperate with the Washington office on many branches of the mineral resources work and also serve the mineral industries and the public at large throughout the West as general bureaus of information and of distribution of Survey publications. The statisticians in charge are Charles W. Henderson, of the Denver office, 409 New U. S. Post Office Building; Victor C. Heikes, of the Salt Lake City office, 312 U. S. Post Office Building; and Charles G. Yale, of the San Francisco office, 305 U. S. Customhouse. Mr. Henderson is author of the mines reports for Colorado, South Dakota, Wyoming, New Mexico, and Texas; Mr. Heikes (assisted by C. N. Gerry) is responsible for the mines reports for Utah, Nevada, Arizona, Montana, Idaho, and Washington; and Mr. Yale contributes the mines reports for California and Oregon and is author also of the current reports on borax and magnesite.

The division of mineral resources works in close cooperation with the division of geology, and most of the reports on mineral resources are now prepared by geologists working in both divisions who specialize on the subjects treated by them. The advantage of the services of these specialists, familiar with the occurrence, treatment, and use of the mineral substances, is well recognized and has broadened the scope and usefulness of the reports.

The authors named in the following list have prepared the reports indicated for 1915:

General:
H. D. McCaskey—Mineral production of the United States (introduction).
Martha B. Clark—Mineral production of the United States (summary).
Metals:
Alfred H. Brooks—Gold, silver, and copper in Alaska (mines report).
Ernest F. Burchard—Iron ore, pig iron, and steel.
B. S. Butler—General report on copper; silver and copper in Michigan (mines report).
J. S. Diller—Chromic iron ore.
John P. Dunlop—Silver, copper, lead, and zinc in Central States, except Michigan (mines report); metals and ores (a summary); statistics of secondary metals; general report on gold and silver (with H. D. McCaskey).
Clarence N. Gerry—Gold, silver, copper, lead, and zinc in Idaho and Washington (mines report).
Victor C. Heikes—Gold, silver, copper, lead, and zinc in Arizona, Utah, Nevada, and Montana (mines report).
Charles W. Henderson—Gold, silver, copper, lead, and zinc in Colorado, New Mexico, South Dakota, Wyoming, and Texas (mines report).
Frank L. Hess—Tin; arsenic; antimony; bismuth; selenium; tellurium; tungsten; vanadium; uranium; radium; nickel; cobalt; titanium; tantalum; molybdenum.
D. F. Hewett—Manganese and manganiferous ores.
James M. Hill—Platinum and allied metals; gold, silver, copper, lead, and zinc in the Eastern States (mines report).
H. D. McCaskey—General report on gold and silver (with J. P. Dunlop); quicksilver.
W. C. Phalen—Bauxite and aluminum.
C. E. Siebenthal—General reports on lead, zinc, and cadmium.
Charles G. Yale—Gold, silver, copper, lead, and zinc in California and Oregon (mines report).
Nonmetals:
E. S. Bastin—Graphite.
Ernest F. Burchard—Fluorspar and cryolite; cement.
J. S. Diller—Asbestos; talc and soapstone.
R. B. Dole—Mineral waters.
James M. Hill—Barytes and strontium.
Frank J. Katz—Abrasive materials; silica (quartz); feldspar.
C. E. Lesher—Fuel briquetting; coke; coal (Part A, production; Part B, distribution and consumption); artificial gas.
G. F. Loughlin—Slate; lime; stone.
Jefferson Middleton—Clay-working industries; sand-lime brick; fuller's earth.
J. D. Northrop—Asphalt, related bitumens, and bituminous rock; petroleum; natural gas.
W. C. Phalen—Phosphate rock; salt, bromine, and calcium chloride; potash salts; sulphur, pyrite, and sulphuric acid.
Waldemar T. Schaller—Gems and precious stones; mica.
Ralph W. Stone—Gypsum; sand and gravel.
Charles G. Yale—Borax; magnesite.

The writer repeats the high appreciation formerly expressed of the work done by his colleagues in the preparation of the reports and of the efficient service rendered by the clerical and stenographic assistants. Some of the statistical clerks have been connected with the collection and tabulation of assigned statistics for so long that they are identified with the subjects involved; and their high degree of skill, their careful scrutiny and criticism of the returns, and their conscientious devotion to duty have gone far to raise the standard of accuracy and completeness of the reports.

COOPERATION WITH STATE GEOLOGICAL SURVEYS.

In the collection of data for the reports on mineral resources the United States Geological Survey has had since 1910 the cooperation of many of the State geological surveys. The statistics so obtained are jointly checked and are the official figures of both State and

Federal surveys. The objects aimed at in cooperation are mainly the avoidance of duplication of effort, and of requests to producers, and of divergent sets of figures bearing an official stamp.

Special acknowledgment is made to the following State officials for their cooperation in the statistical campaign for 1915:

Alabama	Dr. Eugene A. Smith, State geologist, University.
Florida	Dr. E. H. Sellards, State geologist, Tallahassee.
Illinois	Mr. Frank W. DeWolf, director, Urbana.
Iowa	Prof. George F. Kay, director, Iowa City.
Maryland	Dr. William B. Clark, State geologist, Baltimore.
Michigan	Mr. R. C. Allen, director, Lansing.
Minnesota	Dr. W. H. Emmons, director, Minneapolis.
Missouri	Dr. H. A. Buehler, director, Rolla.
New Jersey	Dr. Henry B. Kümmel, State geologist, Trenton.
North Carolina	Dr. Joseph Hyde Pratt, State geologist, Chapel Hill.
Oregon	Prof. H. M. Parks, director, Corvallis.
Virginia	Dr. Thomas L. Watson, director, Charlottesville.
Washington	Prof. Henry Landes, State geologist, Seattle.
Wisconsin	Mr. W. O. Hotchkiss, State geologist, Madison.

For lack of State appropriations the State geologists of New Mexico, Dr. Charles T. Kirk, and of Pennsylvania, Mr. Richard R. Hice, were compelled to forego cooperation for 1915, and the Federal Survey sincerely regrets the legislative failure to support their efforts in upbuilding the mineral resources of their States and in disseminating useful information relative to them.

For the statistical campaign of 1916 the State geologist of New York, Dr. John M. Clarke, assisted by Mr. David H. Newland, has renewed cooperation with the United States Geological Survey. Informal cooperation has been had for some time past between the San Francisco office of the Federal Survey, under Mr. Charles G. Yale, and the California State Mining Bureau, under Mr. F. McN. Hamilton, State mineralogist, assisted by Mr. Walter W. Bradley, and much helpful aid has been interchanged. Many of the State mine inspectors also assist the Federal Survey, especially with regard to statistics of coal output.

MINERAL PRODUCTION.

GENERAL.

In Mineral Resources for 1915, as in preceding reports, the mineral production is treated primarily by subjects. For detailed discussion of the occurrence and production of each mineral substance, by States, the reader should consult the chapters by subjects in the two parts of this report.

The statistics of production include comparisons with earlier years, the figures for which are carried forward each year for convenient reference. The earlier volumes covering the period beginning with 1880, should be consulted for notes on occurrence, development, trade conditions, use, descriptions of mining districts, and other information not carried forward from year to year. For statistics carried forward, however, the reader should always consult the latest volume, as this contains revisions for all the years preceding. For the following summary of mineral production a special and exhaustive comparison and study of earlier figures has been made by Miss Clark, and all revisions for statistics from the earliest volumes to the present

are contained herein. Each volume is normally a supplement to all that have preceded, and the present summary is the most comprehensive statistical revision of earlier statistics of the domestic mineral production.

RAW AND DERIVED PRODUCTS.

In compiling the statistics of mineral production the value of the metallic products is fixed upon the refined or partly refined metals and is, of course, much greater than the value of the ores from which those products are obtained. During recent years the statistics of pig-iron production have been supplemented by accurate determinations of the quantity of iron ore produced and the value thereof, but the quantity and value of the pig iron have been maintained as the units of output. The ores of the precious and semiprecious metals are commonly complex mixtures of several metals, and no quantities or values can be expressed until the contents are extracted in metallic form and become articles of commerce. Chromic iron ore, manganese ore, manganiferous ores, and bauxite (aluminum ore) are marketed as such. In the nonmetals the quantities are expressed and the values placed upon the products in the condition in which they are first sold. With the fuels, with phosphate rock, and with some of the other nonmetals the quantities and values represent the raw product. With cement, however, there is no commercial product until the material is in the finished state as cement. The clay products appear as finished brick, terra cotta, tile, porcelain, and pottery, with the exception of a small quantity of special clays sold raw. The quarry products are sold rough, partly dressed, and finished; salt appears in various refined conditions, as the content of brine, and as rock salt; gypsum is sold at first hand, as crude, as ground, and as calcined. There is no uniformity and there is no way of arriving at the quantities and values of the quarry products except in the condition as first marketed.

In the following State tables the value of iron ore produced is credited to the States from which the ore is produced. The ideal apportionment would probably be based on distribution of value of pig iron back to States from which the ore came that produced the iron, as apportionment is now made for gold, silver, copper, lead, and zinc. This has not yet proved possible, however, for iron.

HISTORICAL REVIEW.

In the summary report on mineral production for 1914 a brief historical résumé was given as an outline of the remarkable growth of the domestic mineral industries from 1880 to 1914. The growth, especially of the metallic products, made a marked advance in 1915, as is shown in the tables that follow; and for 1916 the total value of the mineral products of the United States will undoubtedly run well above $3,000,000,000, or probably three times the total value for 1900, only 16 years ago.

SUMMARY.

By Martha B. Clark.

REVIEW BY PRODUCTS.

GENERAL REMARKS.

The different units of measurement necessarily employed in the mineral industry make it impossible to combine and compare the output of the various minerals except in value.

In 1905, for the first time, the total value of the mineral production in the United States exceeded $1,500,000,000; in 1907 and again in 1912, 1913, 1914, and 1915 it exceeded $2,000,000,000. In 1908 the results of the financial depression of the latter part of 1907 became apparent in the decrease in value of the mineral output, which declined for the year to about $1,595,000,000. In 1909 the general recovery in business carried the value of mineral production up to nearly $1,887,000,000. In 1910 the continued favorable business conditions raised the value to more than $1,991,000,000—almost to the high level of 1907. In 1911 there was a sharp decline in pig iron that brought the total value for the year down to about $1,926,000,000, but the general swing of business in 1912 carried the value of mineral production above $2,244,000,000, thus advancing $318,000,000 beyond the preceding year. In 1913 the maximum production was recorded, the total being more than $2,439,000,000, an increase of $195,000,000 over 1912. In 1914 the value of the mineral production of the United States declined to about $2,115,000,000, but in 1915 it increased more than $278,000,000, or 13 per cent, nearly reaching $2,394,000,000, and falling short of the record value of 1913 by less than 2 per cent.

As heretofore, coal and iron are the most valuable of our mineral products. The value of coal in 1915 was $686,690,000 and that of iron (pig iron being the basis of valuation) $401,410,000. The fuels—coal, natural gas, and petroleum—decreased from $989,700,000 in 1914 to $967,500,000 in 1915, a loss of about $22,000,000, or 2 per cent.

The metallic products reached their maximum value in 1915, increasing nearly $302,000,000, or 44 per cent, from $691,000,000 in 1914 to $993,000,000 in 1915, the next highest value ($904,000,000) being recorded in 1907. The nonmetallic products, valued in 1914 at about $1,423,600,000, showed a decline of 2 per cent in 1915, when the value was $1,393,500,000.

The unspecified products (metallic and nonmetallic), valued in 1915 at $7,450,000, and including the value of antimony other than content of antimonial lead, bismuth, cadmium sulphide, a considerable production of diatomaceous earth for special uses, lithium minerals, magnesium, marls, molybdenum, nickel content of hydrous nickel sulphate, potash salts, selenium, silica sand and sandstone (finely ground), and sulphur, and an estimate of the value of miscellaneous mineral products not collected annually by the Survey, bring the total value of the mineral production for 1915 up to $2,393,831,951.

The rearrangement of minerals alphabetically in the metallic and nonmetallic groups, which it is believed will render the data more convenient for reference, has been completed and some of the figures

have been slightly revised. It is the plan of the Survey to publish the figures in detail for all years beginning with 1880 in Mineral Resources every fifth year. Thus the detailed figures for the early years will next appear in the report for 1920. For the intervening years the mineral chart (showing 10 years in detail and totals for all years) will be inclosed in a pocket, as has been the custom in the past.

The imports cited in this summary are imports "for consumption" (whenever such figures are available) for the calendar year, and may or may not be identical with "general" imports. Merchandise brought into the country late in December, for example, may be entered for consumption or it may be put into a warehouse and not withdrawn for consumption until the following calendar year. It is then credited "for consumption" to the year of its withdrawal from the warehouse.

METALLIC PRODUCTS.

Aluminum.—The consumption of aluminum during 1915 was 99,806,000 pounds, valued at $17,985,500, against 79,129,000 pounds, valued at $14,522,700, in 1914; 72,379,000 pounds, valued at $13,845,000, in 1913; 65,607,000 pounds, valued at $11,907,000, in 1912; and 46,125,000 pounds, valued at $8,084,000, in 1911. The imports of aluminum salts for consumption were valued at $34,320 in 1915, $73,028 in 1914, $66,549 in 1913, and $84,606 in 1912. The exports of aluminum and of the manufactures of aluminum of domestic production were valued at $3,682,117 in 1915, $1,546,510 in 1914, $966,094 in 1913, $1,347,621 in 1912, $1,158,603 in 1911, and $945,215 in 1910.

Antimonial lead.—The production of antimonial lead in 1915 was 23,224 short tons, valued at $3,665,736, against 16,667 tons, valued at $1,572,167, in 1914; 16,665 tons, valued at $1,591,854, in 1913; 13,552 tons, valued at $1,311,348, in 1912; and 14,078 tons, valued at $1,380,556, in 1911.

Antimony.—The antimony contained in antimony ore and in antimonial lead amounted in 1915 to 5,364 short tons, valued at $2,373,760, compared with 2,705 tons, valued at $566,490, in 1914; 2,508 tons, valued at $429,363, in 1913; 1,949 tons, valued at $332,889. in 1912; and 2,254 tons, valued at $386,786, in 1911. The imports of antimony (metal, regulus, and ore) for consumption were valued at $2,992,955 in 1915, $811,765 in 1914, $936,361 in 1913, $859,917 in 1912, and $531,011 in 1911; imports of oxide and salts of antimony were valued at $132,193 in 1915, $315,001 in 1914, $117,169 in 1913, and $81,077 in 1912.

Bauxite.—In 1915 the production of bauxite was 297,041 long tons, valued at the mines at $1,514,834, compared with 219,318 tons, valued at $1,069,194, in 1914; 210,241 tons, valued at $997,698, in 1913; 159,865 tons, valued at $768,932, in 1912; and 155,618 tons, valued at $750,649, in 1911. The imports for consumption were 3,420 long tons, valued at $17,107, in 1915, against 24,844 tons, valued at $96,500, in 1914; 21,456 tons, valued at $85,746, in 1913; 26,214 tons, valued at $95,431, in 1912; and 43,222 tons, valued at $164,301, in 1911.

Bismuth.—A production of bismuth (saved as a by-product in electrolytic refining of lead) was reported for 1915, but the Survey is not at liberty to publish the figures. The production for 1914

was 220,000 pounds. valued at $426,000, compared with 157,300 pounds, valued at $273,650, in 1913. The imports for consumption were valued at $108,288 in 1915, $165,208 in 1914, $213,257 in 1913, and $316,440 in 1912.

Cadmium.—The production of metallic cadmium in 1915 was 91,415 pounds, valued at $108,443, compared with 91,409 pounds, valued at $81,205, in 1914; 54,198 pounds, $41,838, in 1913; 52,508 pounds, $39,875, in 1912; and 26,152 pounds, $17,566, in 1911. In addition to the metallic cadmium, the production of cadmium sulphide has been as follows: 10,624 pounds, $12,057, in 1915; 22,723 pounds, $20,241, in 1914; 17,302 pounds, $12,136, in 1913; 8,998 pounds, $6,400, in 1912; and 2,392 pounds, $1,674, in 1911. The imports of cadmium for consumption were valued at $284 in 1915, $368 in 1914, $1,232 in 1913, and $3,764 in 1912.

Chromic iron ore.—The marketed production of chromic iron ore in 1915 was 3,281 long tons, valued at $36,744, compared with 591 tons, valued at $8,715, in 1914; 255 tons, valued at $2,854, in 1913; 201 tons, valued at $2,753, in 1912; and 120 tons, valued at $1,629, in 1911. The imports of chromic iron ore for consumption were 76,455 long tons, valued at $780,061, in 1915, against 80,736 tons, valued at $695,645, in 1914; 65,180 tons, valued at $622,821, in 1913; 53,929 tons, valued at $499,818, in 1912; and 37,540 tons, valued at $407,958, in 1911. The imports of chromic acid and chromates of potash were valued at $3,657 in 1915, $3,972 in 1914, $2,919 in 1913, and $4,461 in 1912.

Copper.—The production of copper in 1915 from domestic ores was 1,388,009,527 pounds, valued at New York City at $242,902,000, against 1,150,137,192 pounds, valued at $152,968,000, in 1914; 1,224,484,098 pounds, valued at $189,795,035, in 1913; 1,243,268,720 pounds, valued at $205,139,338, in 1912; and 1,097,232,749 pounds, valued at $137,154,092, in 1911. The imports for consumption were valued at $44,410,965 in 1915, against $39,491,973 in 1914, and $57,639,490 in 1913; and the exports in 1915 at $117,703,941, against $117,633,145 in 1914, and $146,327,621 in 1913.

Ferroalloys.—In the iron report for 1911 the United States Geological Survey undertook for the first time to present the statistics of production of ferroalloys separately from those of pig iron, with which they had been included. As reported, the marketed production of ferroalloys in 1915 was 388,644 long tons, valued at the furnaces at $17,450,385, compared with 255,524 tons, valued at $9,350,245, in 1914; 296,207 tons, valued at $13,015,362, in 1913; 328,685 tons, valued at $12,223,776, in 1912; and 253,375 tons, valued at $8,377,832, in 1911. Part of the output is derived from foreign ores. These quantities do not represent the total production of the United States, as considerable tonnages of electrically produced ferroalloys have not been reported to the Survey. The Bureau of Foreign and Domestic Commerce reports the following values of imports of ferroalloys for consumption in 1913, 1914, and 1915: Chrome and ferrochrome, $51,415 in 1913, $21,553 in 1914, and $1,662 in 1915; ferrophosphorus, none imported in 1913, $1,136 in 1914, and $617 in 1915; ferrosilicon, $449,871, $341,925, and $311,219; ferromanganese, $5,682,915, $3,619,607, and $3,333,699; molybdenum and ferromolybdenum, $15,939, $59, and $203; spiegeleisen, $2,173, $71,147, and $5,110; titanium and ferrotitanium, $7,198,

$8,356, and none in 1915; tungsten and ferrotungsten, $835,212, $222,447, and $9,588—a total of $7,044,723 in 1913, $4,286,230 in 1914, and $3,662,098 in 1915.

Gold.—The production of gold in 1915 was 4,887,602 fine ounces, valued at $101,035,700, compared with 4,572,976 ounces, valued at $94,531,800, in 1914; 4,299,784 ounces, valued at $88,884,400, in 1913; 4,520,717 ounces, valued at $93,451,500, in 1912; and 4,687,053 ounces, valued at $96,890,000, in 1911.

Iron (ore and pig).—The marketed production of iron ore in 1915 amounted to 55,493,100 long tons, valued at the mines at $101,288,984, compared with 39,714,280 tons, valued at $71,905,079, in 1914; 59,643,098 tons, valued at $130,905,558, in 1913; 57,017,614 tons, valued at $107,050,153, in 1912; and 41,092,447 tons, valued at $86,716,575, in 1911. The imports of iron ore for consumption were valued at $4,181,645 in 1915, $4,482,242 in 1914, and $8,332,777 in 1913; and the exports at $2,181,629 in 1915, $1,794,193 in 1914, $3,513,419 in 1913, $3,537,289 in 1912, and $2,653,448 in 1911.

The marketed production of pig iron in 1915 was 30,384,486 long tons, valued at the furnaces at $401,409,604, compared with 22,263,263 tons, valued at $298,777,429, in 1914; 30,388,935 tons, valued at $458,342,345, in 1913; 30,180,969 tons, valued at $420,563,388, in 1912, and 23,257,288 tons, valued at $327,334,624, in 1911. The exports of pig iron in 1915, 1914, and 1913 were 224,509 long tons, valued at $3,667,167, 114,423 tons, valued at $1,638,102, and 277,648 tons, valued at $4,026,306, respectively.

Lead.—The production of refined lead from domestic ores in 1915 was 507,026 short tons, valued at New York City at $47,660,000, compared with 512,794 tons, valued at $39,998,000, in 1914; 411,878 tons, valued at $36,245,264, in 1913; 392,517 tons, valued at $35,326,530, in 1912; and 391,995 tons, valued at $35,279,550 in 1911. The imports of lead for consumption were valued at $772,955 in 1915, against $504,978 in 1914, $572,980 in 1913, $605,551 in 1912, and $631,654 in 1911; and the exports of lead at $10,067,895 in 1915, $5,519,908 in 1914, and $738,135 in 1913.

Magnesium.—So far as is known magnesium had not been produced on a commercial scale in the United States until 1915, though experiments looking toward that end had been performed by various firms at different times, and especially since the beginning of the European war in 1914. The total production for 1915 was 87,500 pounds, valued at about $440,000.

Manganese ore.—The marketed production of manganese ore in 1915 was 9,709 long tons, valued at the mines at $113,309, compared with 2,635 tons, valued at $27,377, in 1914; 4,048 tons, valued at $40,480, in 1913; 1,664 tons, valued at $15,723, in 1912; and 2,457 tons, valued at $24,586, in 1911. The imports of manganese ore for consumption were 320,778 long tons, valued at $2,655,980, against 283,294 tons, valued at $2,024,120, in 1914; 345,090 tons, valued at $2,029,680, in 1913; and 300,661 tons, valued at $1,769,184, in 1912.

Manganiferous ore.—In 1915 the marketed production of manganiferous ore (exclusive of Lake Superior ores so low in manganese as to be classed with iron ore) was 185,238 long tons, valued at the mines at $266,380, against 98,265 tons, valued at $218,497, in 1914; 59,403 tons, valued at $25,124, in 1913; 51,517 tons, valued at $19,942, in 1912; and 44,437 tons, valued at $114,918, in 1911.

Molybdenum.—The production of molybdenum in 1915 was valued at about $115,000. There was also a small production in 1914, but none is known to have been produced in 1913. Imports of molybdenum and ferromolybdenum were valued at $203 in 1915, $59 in 1914, $15,939 in 1913, $4,670 in 1912, and $11,409 in 1911.

Nickel.—Metallic nickel and nickel in salts and speiss, amounting to 1,644,065 pounds, valued at $538,222, was saved as a by-product in electrolytic refining of copper in 1915, compared with 845,334 pounds, valued at $313,000, in 1914; and 481,565 pounds, valued at $79,393, in 1913. The imports of nickel for consumption were valued at $7,629,686 in 1915, against $5,028,818 in 1914, $6,600,755 in 1913, $5,758,967 in 1912, and $4,050,030 in 1911. The exports were valued at $10,128,514 in 1915, $9,455,528 in 1914, $9,686,794 in 1913, $8,515,332 in 1912, and $8,283,777 in 1911.

Platinum and allied metals.—The production of refined platinum and allied metals in 1915 was 8,665 fine ounces, valued at New York City at $478,688, compared with 6,324 ounces, valued at $280,885, in 1914; 1,034 ounces, valued at $46,530, in 1913; 1,005 ounces, valued at $45,778, in 1912; and 940 ounces, valued at $40,890, in1911. The imports of platinum (manufactured and unmanufactured) for consumption were valued at $2,302,888 in 1915, $2,908,353 in 1914, $5,040,210 in 1913, $4,503,682 in 1912, and $4,866,207 in 1911. In 1915 the imports of the platinum-group metals (other than platinum) for consumption were: Iridium, $243,266; osmiridium, $5,737; osmium, $787; palladium, $103,623; rhodium, none; and ruthenium, none—a total of $353,413. In 1914: Iridium, $112,430; osmiridium, $84,363; osmium, none; palladium, $69,547; rhodium, $1,905; and ruthenium, $576—a total of $268,821. In 1913 these imports were: Iridium, $295,864; osmiridium, $11,872; osmium, $42,924; palladium, $364,738; rhodium, $3,668; and ruthenium, none—a total of $719,066.

Quicksilver.—The production of quicksilver in 1915 amounted to 21,033 flasks (75 pounds net), valued at San Francisco at $1,826,912, against 16,548 flasks, valued at $811,680, in 1914; 20,213 flasks, valued at $813,171, in 1913; 25,064 flasks, valued at $1,053,941, in 1912; and 21,256 flasks, valued at $977,989, in 1911. The imports for consumption were valued at $282,752 in 1915, $271,984 in 1914, $75,361 in 1913, $39,920 in 1912, and $251,386 in 1911; and the exports at $225,509 in 1915, $70,753 in 1914, $43,574 in 1913, $13,360 in 1912, and $13,995 in 1911.

Selenium.—The Survey is not at liberty to publish the production of selenium in 1915, which was all saved as a by-product in electrolytic refining of copper. The output for 1914 was 22,867 pounds, valued at $34,277; for 1913 it was 29,097 pounds, valued at about $46,900.

Silver.—The production of silver in 1915 was 74,961,075 fine ounces, with an estimated commercial value of $37,397,300,[1] against 72,455,100 ounces, valued at $40,067,700, in 1914; 66,801,500 ounces, valued at $40,348,100, in 1913; 63,766,800 ounces, valued at $39,197,500, in 1912; and 60,399,400 ounces, valued at $32,615,700, in 1911.

Tantalum minerals.—No production of tantalum minerals was reported for 1912, 1913, 1914, or 1915. Very small quantities of tantalum ore (columbite) were reported mined in 1911, 1910, and 1909, but none was reported marketed.

[1] Value assigned by U. S. Mint.

Tellurium.—A small quantity of tellurium was obtained from copper anode muds in 1913. The quantity saved in 1914 and 1915 was inconsiderable.

Tin.—In 1915 tin ore (equivalent to 102 tons of metallic tin), valued at $78,846, was reported, against 104 tons of metallic tin, valued at $66,560, in 1914; 120 tons of 60 per cent ore in 1913, valued at $46,699; and 147 tons of 60 per cent ore in 1912, valued at $124,800. In 1911 the output of tin was valued at $56,635. The imports of tin for consumption were valued at $38,854,579 in 1915, $32,943,059 in 1914, $46,946,756 in 1913, $50,372,478 in 1912, and $43,346,394 in 1911.

Titanium minerals.—In 1915 the Virginia mines reported 250 short tons of rutile, valued at $27,500, against 94 tons of rutile, valued at $11,280, and 89 tons of ilmenite, valued at $4,895, in 1914; 305 tons of rutile, valued at $49,000, in 1913; 275 tons of rutile, valued at $27,500, in 1912; and no production in 1911. Imports of titanium and ferrotitanium were valued at $8,356 in 1914, $7,198 in 1913, $7,631 in 1912, $22,700 in 1911, but none were reported in 1915.

Tungsten ore.—The production of tungsten ore (60 per cent concentrates) in 1915 was 2,332 short tons, valued at $4,100,000, against 990 tons, valued at $435,000, in 1914; 1,537 tons, $672,118, in 1913; 1,330 tons, $502,158, in 1912; and 1,139 tons, $407,985, in 1911. The imports of tungsten ore for consumption were valued at $1,044,986 in 1915, $139,687 in 1914, and $213,122 in 1913. Tungsten and ferrotungsten imported were valued at $9,588 in 1915, $222,447 in 1914, $835,212 in 1913, and $323,872 in 1912.

Uranium and vanadium minerals.—The production of uranium and vanadium minerals in 1915 was valued at $693,750, compared with $941,300 in 1914, and $609,361 in 1913. Imports of ferrovanadium, valued at $2,623, were reported for 1911; none were reported for 1912, 1913, 1914, and 1915. Imports of uranium salts and oxide, including some radium salts, were valued at $17,288 in 1915, $63,055 in 1914, and $34,319 in 1913.

Zinc.—The production of zinc in 1915 from domestic ores was 458,135 short tons, $113,617,000 being the sales value, against 343,418 tons, valued at St. Louis at $35,029,000, in 1914; 337,252 tons, $37,772,224, in 1913; 323,907 tons, $44,699,166, in 1912; and 271,621 tons, $30,964,794, in 1911. The imports of zinc ore and manufactures of zinc for consumption were valued at $1,585,494 in 1915, $425,205 in 1914, $1,079,994 in 1913, $2,114,435 in 1912, and $435,329 in 1911. The exports of domestic zinc ore and domestic manufactures of zinc were valued at $32,253,001 in 1915, $9,381,050 in 1914, $1,735,099 in 1913, $1,846,301 in 1912, and $1,935,677 in 1911.

Metals and ores.—The chapter on metals and ores was published for the first time for the year 1909. The output of metals in the United States in 1915 from domestic ores was valued at $961,575,662, from foreign sources at $147,058,033, a total of $1,108,633,695, against $679,174,009 from domestic sources, $115,735,845 from foreign sources, the total being $794,909,854 in 1914. The output of crude metallic ores of all kinds from domestic mines amounted to 144,742,104 short tons in 1915 and to 113,579,697 tons in 1914.

NONMETALLIC PRODUCTS.

Arsenious oxide.—The production of arsenious oxide (white arsenic) in 1915 amounted to 5,498 short tons, valued at $302,116, against 4,670 tons, valued at $313,147, in 1914; 2,513 tons, valued at $159,236, in 1913; 3,141 tons, valued at $190,757, in 1912; and 3,132 tons, valued at $73,408, in 1911. The imports of "arsenic or arsenious acid" and "arsenic sulphide or orpiment" for consumption were valued at $267,776 in 1915, $273,713 in 1914, $410,446 in 1913, and $428,741 in 1912.

Asbestos.—The production of asbestos in 1915 was 1,731 short tons, valued at $76,952, against 1,247 tons, valued at $18,965, in 1914; 1,100 tons, valued at $11,000, in 1913; 4,403 tons, valued at $87,959, in 1912; and 7,604 tons, valued at $119,935, in 1911. The imports of asbestos (manufactured and unmanufactured) for consumption were valued at $2,121,003 in 1915, $1,779,223 in 1914, $2,307,666 in 1913, $1,820,528 in 1912, and $1,704,491 in 1911.

Asphalt.—Under the term "asphalt" are included the various bitumens or hydrocarbon minerals not discussed elsewhere under petroleum. The production in 1915 was 740,254 short tons, valued at $5,242,073, compared with 440,571 tons, valued at $3,659,092, in 1914; 529,190 tons, valued at $5,282,370, in 1913; 449,510 tons, valued at $4,620,731, in 1912; and 364,266 tons, valued at $3,991,109, in 1911. The imports of asphalt for consumption were valued at $680,357 in 1915, $675,618 in 1914, $910,611 in 1913, $920,145 in 1912, and $789,236 in 1911. The exports for the years 1915, 1914, and 1913 were valued at $1,174,637, $1,247,020, and $1,679,411, respectively

Barytes and strontium.—The production of crude barytes in 1915 was 108,547 short tons, valued at $381,032, compared with 52,747 tons, valued at $155,647, in 1914; 45,298 tons, valued at $156,275, in 1913; 37,478 tons, valued at $153,313, in 1912; and 38,445 tons, valued at $122,792, in 1911. The imports of barytes (manufactured and unmanufactured) for consumption were valued at $15,613 in 1915, $77,265 in 1914, $99,564 in 1913, and $79,315 in 1912. The imports of barium compounds were valued at $438,826 in 1915, $778,804 in 1914, $391,470 in 1913, and $376,017 in 1912. No strontium was reported as mined during 1915, 1914, or 1913. Imports of strontia oxide, protoxide of strontium, and strontianite were valued at $6,411 in 1915, $1,016 in 1914, and at $2,284 in 1913.

Borax.—The production of crude borax in 1915 was 67,003 short tons, valued at $1,677,099, against 62,400 tons, valued at $1,464,400, in 1914; 58,051 tons, valued at $1,491,530, in 1913; 42,315 tons, valued at $1,127,813, in 1912; and 53,330 tons, valued at $1,569,151, in 1911. The imports of borax and borates for consumption were valued at $21,281 in 1915, $19,412 in 1914, $18,534 in 1913, and $11,249 in 1912.

Bromine.—The production of bromine in 1915 amounted to 855,857 pounds, valued at $856,307, against 576,991 pounds, valued at $203,094, in 1914; 572,400 pounds, valued at $115,436, in 1913; 647,200 pounds, valued at $145,805, in 1912; and 651,541 pounds, valued at $110,902, in 1911.

Calcium chloride.—The production of calcium chloride in 1915 was 20,535 short tons, valued at $130,830, against 19,403 tons, valued at

$121,766, in 1914; 19,611 tons, valued at $130,030, in 1913; 18,550 tons, valued at $117,272, in 1912; and 14,606 tons, valued at $91,215, in 1911.

Cement.—The total marketed production of the principal hydraulic cements in the United States in 1915 was 87,685,222 barrels (380 pounds net), valued at the mills at $75,155,102, compared with 87,257,552 barrels, valued at $80,533,203, in 1914; 89,541,348 barrels, valued at $89,550,527, in 1913; and 85,925,651 barrels, valued at $69,554,385, in 1912. The marketed production of Portland cement in 1915 was 86,891,681 barrels, valued at $74,756,674, compared with 86,437,956 barrels, valued at $80,118,475, in 1914; 88,689,377 barrels, valued at $89,106,975, in 1913; and 85,012,556 barrels, valued at $69,109,800, in 1912. The marketed production of natural cement in 1915 was 750,863 barrels, valued at $358,627, compared with 751,285 barrels, valued at $351,370, in 1914; 744,658 barrels, valued at $345,889, in 1913; and 821,231 barrels, valued at $367,222, in 1912. The marketed production of puzzolan cement in 1915 amounted to 42,678 barrels, valued at $39,801, against 68,311 barrels, valued at $63,358, in 1914; 107,313 barrels, valued at $97,663, in 1913; and 91,864 barrels, valued at $77,363, in 1912. The imports of hydraulic cements for consumption were valued at $57,174 in 1915, $194,053 in 1914, $139,416 in 1913, and $93,558 in 1912; and the exports at $3,361,451 in 1915, $3,088,809 in 1914, $4,270,666 in 1913, and $6,160,341 in 1912.

Clay products and raw clay.—The value of all clay products in 1915 was $163,120,232, compared with $164,986,983 in 1914, $181,289,132 in 1913, $172,811,275 in 1912, and $162,236,181 in 1911. The imports of brick and tile, etc., for consumption were valued at $159,415 in 1915, against $207,644 in 1914, $276,677 in 1913, and $215,379 in 1912; and the exports at $1,531,210 in 1915, $3,051,103 in 1914, $4,228,908 in 1913, and $3,823,111 in 1912. The pottery products were valued at $37,325,388 in 1915, $35,398,161 in 1914, $37,992,375 in 1913, $36,504,164 in 1912, and $34,518,560 in 1911. The imports of pottery for consumption amounted to $6,612,931 in 1915, against $8,349,442 in 1914, $10,177,451 in 1913, $9,555,530 in 1912, and $10,638,616 in 1911; and the exports of pottery were valued at $1,174,030 in 1915, $526,902 in 1914, $559,331 in 1913, and $1,177,784 in 1912.

Clay mined and sold as unmanufactured clay amounted to 2,362,954 short tons, valued at $3,971,941, in 1915, against 2,209,860 tons, valued at $3,756,568, in 1914; and 2,647,989 tons, valued at $4,180,459, in 1913. The imports of kaolin or china clay for consumption were valued at $1,152,778 in 1915, $1,927,425 in 1914, $1,623,993 in 1913, and $1,629,105 in 1912. The imports of other clays for consumption amounted in 1915 to $165,369, against $359,993 in 1914, and $382,782 in 1913.

Coal.—In 1915 the output of coal was 531,619,487 short tons, valued at the mines at $686,691,186, compared with 513,525,477 tons, valued at $681,490,643, in 1914; 569,960,219 tons, valued at $760,416,079, in 1913; 534,466,580 tons, valued at $695,606,071, in 1912; and 496,371,126 tons, valued at $626,565,211, in 1911.

The production of bituminous coal (which includes all coals except anthracite mined in Pennsylvania) amounted in 1915 to 442,624,426 short tons, valued at the mines at $502,037,688, compared with

422,703,970 tons, valued at $493,309,244, in 1914; 478,435,297 tons, valued at $565,234,952, in 1913; 450,104,982 tons, valued at $517,983,445, in 1912; and 405,907,059 tons, valued at $451,375,819, in 1911. The imports of bituminous coal for consumption were valued at $4,410,772 in 1915, $3,902,881 in 1914, $3,853,930 in 1913, $4,509,066 in 1912, and $3,604,797 in 1911. The exports were valued at $42,817,341 (not including bunker coal valued at $25,192,956) in 1915; $34,104,903 (not including bunker coal valued at $24,145,735) in 1914; and at $45,449,664 (not including bunker coal valued at $25,036,272) in 1913.

The output of Pennsylvania anthracite in 1915 was 79,459,876 long tons, valued at the mines at $184,653,498, compared with 81,090,631 tons, valued at $188,181,399, in 1914; 81,718,680 tons, valued at $195,181,127, in 1913; 75,322,855 tons, valued at $177,622,626, in 1912; and 80,771,488 tons, valued at $175,189,392, in 1911. The imports of anthracite for consumption were valued at $4,224 in 1915, $25,380 in 1914, $5,620 in 1913, and $8,329 in 1912; and the exports at $18,429,255 in 1915, $20,211,072 in 1914, and $21,959,850 in 1913.

Coal briquets.—The production of coal briquets in the United States in 1915 was 221,537 short tons, valued at $1,035,716, against 250,635 tons, valued at $1,154,678, in 1914; 181,859 tons, valued at $1,007,327, in 1913; 220,064 tons, valued at $952,261, in 1912; and 218,443 tons, valued at $808,721, in 1911.

Cobalt oxide.—No cobalt oxide has been produced in this country from domestic ores since 1909. The imports of cobalt (oxide, ore, and zaffer) for consumption were valued at $219,111 in 1915, $274,538 in 1914, $95,735 in 1913, $83,080 in 1912, and $59,151 in 1911.

Coke.—The production of coke in 1915 amounted to 41,581,150 short tons, valued at the ovens at $105,503,868, against 34,555,914 tons, valued at $88,334,217, in 1914; 46,299,530 tons, valued at $128,922,273, in 1913; 43,983,599 tons, valued at $111,805,113, in 1912; and 35,551,489 tons, valued at $84,130,849, in 1911. The imports of coke for consumption were valued at $222,382 in 1915, $551,104 in 1914, $435,157 in 1913, and at $488,398 in 1912, and the exports at $3,092,498 in 1915, $2,233,686 in 1914, $3,309,930 in 1913, and $3,002,742 in 1912.

Diatomaceous (infusorial) earth and tripoli.—The value of the diatomaceous (infusorial) earth and tripoli produced in 1915 was $611,021 (exclusive of the value of a considerable production for special uses which the Survey is not at liberty to publish) against $252,327 in 1914, $285,821 in 1913, $125,446 in 1912, and $147,462 in 1911. The imports of diatomaceous earth, rottenstone, and tripoli for consumption were valued at $27,333 in 1915, $20,004 in 1914, $28,696 in 1913, and $24,253 in 1912.

Emery and corundum.—No corundum has been produced since 1906. The output of emery in 1915 was 3,063 short tons, valued at $31,131, against 485 tons, valued at $2,425, in 1914; 957 tons, valued at $4,785, in 1913; and 992 tons, valued at $6,652, in 1912. The imports of emery and corundum for consumption were valued at $271,649 in 1915, $383,436 in 1914, $474,299 in 1913, and $491,725 in 1912.

Feldspar.—The production of feldspar in 1915 was 113,769 short tons, valued at $629,356, against 135,419 tons, valued at $629,873, in 1914; 120,955 tons, valued at $776,551, in 1913; 86,572 tons, valued at $520,562, in 1912; and 92,700 tons, valued at 579,008, in 1911.

Fertilizers.—Fertilizers, including apatite, bone dust, guano, kainite, kieserite, crude phosphates, and other manures, are shown under phosphate rock and under potash salts, and sodium nitrate is mentioned as such.

Fluorspar and cryolite.—The production of fluorspar in 1915 was 136,941 short tons, valued at the mines at $764,475, compared with 95,116 tons, valued at $570,041, in 1914; 115,580 tons, valued at $736,286, in 1913; 116,545 tons, valued at $769,163, in 1912; and 87,048 tons, valued at $611,447, in 1911. The imports of fluorspar for consumption were 7,167 short tons, valued at $22,878, in 1915, compared with 10,205 tons, valued at $38,943, in 1914; 22,682 tons, valued at $71,463 in 1913; and 26,176 tons, valued at $71,616, in 1912.

No cryolite is produced in the United States. The imports were valued at $82,750 in 1915, $94,424 in 1914 and $52,557 in 1913

Fuller's earth.—The production of fuller's earth in 1915 was 47,901 short tons, valued at the mines at $489,219, against 40,981 tons, valued at $403,646, in 1914; 38,594 tons, valued at $369,750, in 1913; 32,715 tons, valued at $305,522, in 1912; and 40,697 tons, valued at $383,124, in 1911. The imports of fuller's earth (manufactured and unmanufactured) for consumption were valued at $152,493 in 1915, $195,083 in 1914, $146,001 in 1913, and $145,337 in 1912.

Garnet.—The production of abrasive garnet in 1915 amounted to 4,301 short tons, valued at $139,584, against 4,231 tons, valued at $145,510, in 1914; 5,308 tons, valued at $183,422, in 1913; 4,947 tons, valued at $163,237, in 1912; and 4,076 tons, valued at $121,748, in 1911. No record is kept of imports of abrasive garnet.

Gems and precious stones.—The value of gems and precious stones found in the United States in 1915 was $170,431, against $124,651 in 1914, $319,454 in 1913, $319,722 in 1912, and $343,692 in 1911. Imports of precious stones (including pearls) for consumption were valued at $26,193,862 in 1915, against $19,211,084 in 1914, $45,431,998 in 1913, $41,363,325 in 1912, and $40,820,436 in 1911.

Graphite.—The production of amorphous graphite in 1915 was 1,181 short tons, valued at $12,358, compared with 1,725 tons, valued at $38,750, in 1914; 2,243 tons, valued at $39,428, in 1913; 2,063 tons, valued at $32,894, in 1912; and 1,223 tons, valued at $32,415, in 1911. The production of crystalline graphite in 1915 amounted to 7,074,370 pounds, valued at $417,273, compared with 5,220,539 pounds, valued at $285,368, in 1914; 5,064,727 pounds, valued at $254,328, in 1913; 3,543,771 pounds, valued at $187,689, in 1912; and 4,790,000 pounds, valued at $256,050, in 1911. The production of manufactured graphite in 1915 was 5,084,000 pounds, valued at $99,633, compared with 10,455,139 pounds, valued at $698,800, in 1914; and 13,633,342 pounds, valued at $973,397, in 1913. The imports of graphite for consumption were valued at $2,241,163 in 1915, $1,398,209 in 1914, and at $2,109,791 in 1913.

Grindstones and pulpstones.—The value of all kinds of grindstones and pulpstones produced in 1915 was $648,479, against $689,344 in 1914, $855,627 in 1913, $916,339 in 1912, and $907,316 in 1911. The imports for consumption were valued at $68,892 in 1915, $109,539 in 1914, $139,386 in 1913, and $131,080 in 1912.

Gypsum.—The output of gypsum in 1915 was 2,447,611 short tons, valued at $6,596,893, compared with 2,476,465 tons, valued at $6,895,989, in 1914; 2,599,508 tons, valued at $6,774,822, in 1913;

2,500,757 tons, valued at $6,563,908, in 1912; and 2,323,970 tons, valued at $6,462,035, in 1911. The imports of gypsum for consumption were valued at $389,759 in 1915, $444,841 in 1914, $556,922 in 1913, $488,481 in 1912, and $450,806 in 1911.

Lime.—The production of lime in 1915 was 3,589,699 short tons, valued at $14,336,756, against 2,380,928 tons, valued at $13,268,938, in 1914; 3,595,390 tons, valued at $14,648,362, in 1913; 3,529,462 tons, valued at $13,970,114, in 1912; and 3,392,915 tons, valued at $13,689,054, in 1911. The imports of lime for consumption were 1,956 short tons, valued at $22,489, in 1915, against 3,455 tons, valued at $33,670, in 1914; and 4,139 tons, valued at $48,538, in 1913. The exports were valued at $106,312 in 1915, compared with $170,744 in 1914, and $212,345 in 1913.

Lithium minerals.—A small production of lithium minerals was reported in 1915 as in previous years, but the statistics may not be published, as doing so would disclose individual figures.

Magnesite.—The production of crude magnesite continues to be limited to California. During 1915 the production was 30,499 short tons, valued at $274,491, against 11,293 tons, valued at $124,223, in 1914; 9,632 tons, valued at $77,056, in 1913; 10,512 tons, valued at $84,096, in 1912; and 9,375 tons, valued at $75,000, in 1911. The imports of magnesia and magnesite for consumption were valued at $516,469 in 1915, $1,453,508 in 1914, $1,805,274 in 1913, and $1,430,542 in 1912.

Marls.—No considerable production of marls has been reported since 1908. There was a very small output in 1915 as in preceding years.

Mica.—The production of mica in 1915 consisted of 3,959 short tons of scrap mica, valued at $50,510, and 553,821 pounds of sheet mica, valued at $378,259, against 3,730 tons of scrap, valued at $51,416, and 556,933 pounds of sheet, valued at $278,540, in 1914; 5,322 tons of scrap, valued at $82,543, and 1,700,677 pounds of sheet, valued at $353,517, in 1913; 3,226 tons of scrap, valued at $49,073, and 845,483 pounds of sheet, valued at $282,823, in 1912; and 3,512 tons of scrap, valued at $45,550, and 1,887,201 pounds of sheet, valued at $310,254, in 1911. The imports of mica for consumption were valued at $692,269 in 1915, $629,484 in 1914, $947,783 in 1913, $755,584 in 1912, and $505,552 in 1911.

Millstones.—The value of the production of millstones in 1915 was $53,480, against $43,316 in 1914, $56,163 in 1913, and $71,414 in 1912. The imports of burrstones and millstones for consumption were valued at $17,027 in 1915, $15,000 in 1914, $40,198 in 1913, and $27,562 in 1912.

Mineral paints.—The marketed production of mineral paints (natural and zinc and lead pigments) in 1915 amounted to 198,825 short tons, valued at $15,514,059, compared with 173,557 tons, valued at $10,612,100, in 1914; 168,168 tons, valued at $9,533,306, in 1913; 181,154 tons, valued at $10,069,588, in 1912; and 143,350 tons, valued at $7,842,583, in 1911. Imports of ocher for consumption were valued at $137,823 in 1915, $141,704 in 1914, $143,720 in 1913, and $148,306 in 1912; of sienna, at $65,283 in 1915, $63,958 in 1914, $48,535 in 1913, and $45,794 in 1912; of umber, at $32,182 in 1915, $45,280 in 1914, $36,771 in 1913, and $31,626 in 1912; of zinc oxide, at $154,149 in 1915, $302,838 in 1914, $434,156 in 1913, and $386,153 in 1912.

Mineral waters.—The marketed production of mineral waters in 1915 was 52,113,503 gallons, valued at $5,138,794, compared with 54,358,466 gallons, valued at $4,892,328, in 1914; 57,867,399 gallons, valued at $5,631,391, in 1913; 62,281,201 gallons, valued at $6,615,671, in 1912; and 63,788,552 gallons, valued at $6,837,888, in 1911. The imports of mineral waters for consumption were valued at $551,648 in 1915, $857,707 in 1914, $955,788 in 1913, and $930,091 in 1912.

Natural gas and gasoline.—The value of natural gas produced in 1915 was $101,312,381, compared with $94,115,524 in 1914, $87,846,677 in 1913, $84,563,957 in 1912, and $74,621,534 in 1911. No imports of natural gas have been reported since 1909, when they were valued at $6,060, compared with $22,003 in 1908.

The production of gasoline extracted from casing-head gas (natural gas from oil wells) amounted in 1915 to 65,364,665 gallons, valued at $5,150,823, against 42,652,632 gallons, valued at $3,105,909, in 1914; 24,060,817 gallons, valued at $2,458,443, in 1913; 12,081,179 gallons, valued at $1,157,476, in 1912; and 7,425,839 gallons, valued at $531,704, in 1911. The imports of gasoline were valued at $34,750 in 1915, $587 in 1914, and at $1,661 in 1913, and the exports in 1915, 1914, and 1913, at $13,164,159, $19,897,613, and $17,418,777, respectively.

Oilstones, etc.—The production of oilstones, etc., in 1915 was valued at $115,175, against $167,948 in 1914, $207,352 in 1913, $232,218 in 1912, and $214,991 in 1911. The imports for consumption were valued at $14,247 in 1915, $33,655 in 1914, $40,222 in 1913, and $45,398 in 1912.

Peat.—The production of peat in 1915 was valued at $288,537, against $309,692 in 1914, $197,200 in 1913, $228,572 in 1912, and $272,114 in 1911. The imports of peat for consumption were valued at $48,142 in 1915, $57,542 in 1914, and $55,719 in 1913.

Petroleum.—The marketed output of crude petroleum in 1915 was 281,104,104 barrels (42 gallons each), valued at $179,462,890, against 265,762,535 barrels, valued at $214,125,215, in 1914; 248,446,230 barrels, valued at $237,121,388, in 1913; 222,935,044 barrels, valued at $164,213,247, in 1912; and 220,449,391 barrels, valued at $134,044,752, in 1911. The imports of petroleum (including benzine) for consumption were valued at $10,444,210 in 1915, $11,464,879 in 1914, $12,945,619 in 1913, $6,082,881 in 1912, and $2,410,884 in 1911; and the exports of petroleum and its products (mineral oils except gasoline), were valued at $129,777,510 in 1915, against $120,002,974 in 1914, $131,897,632 in 1913, $124,210,382 in 1912, and $105,922,848 in 1911. The imports of ozokerite and paraffin (oil and wax) for consumption were valued at $638,518 in 1915, against $860,921 in 1914, $982,352 in 1913, $1,018,524 in 1912, and $787,363 in 1911. The exports of paraffin and paraffin wax were valued at $12,535,430 in 1915, $6,434,831 in 1914, $8,176,831 in 1913, $9,602,758 in 1912, and $7,047,856 in 1911.

Phosphate rock.—The marketed production of phosphate rock in 1915 amounted to 1,835,667 long tons, valued at the mines at $5,413,449, compared with 2,734,043 tons, valued at $9,608,041, in 1914; 3,111,221 tons, valued at $11,796,231, in 1913; 2,973,332 tons, valued at $11,675,774, in 1912; and 3,053,279 tons, valued at $11,900,693, in 1911. The quantity of phosphate rock reported as

mined during 1915 was 1,935,341 long tons, against 2,649,174 tons in 1914, and 3,152,208 tons mined in 1913. The imports of crude phosphates, guano, kainite, manure salts, etc., for consumption were valued at $3,970,039 in 1915, $9,921,439 in 1914, $10,819,253 in 1913, and $8,893,090 in 1912. The exports of phosphate rock were 253,549 long tons, valued at $1,605,639, in 1915, against 964,114 tons, valued at $6,771,652, in 1914; 1,366,508 tons, valued at $9,996,580, in 1913; and 1,206,520 tons, valued at $8,996,456, in 1912.

Potash salts.—The year 1915 was epoch making in the domestic potash industry. There were produced in this country that year soluble potash salts valued at $342,000. Quantities are not given for the reason that the product sold came from diverse sources and contained varying proportions of potash. Though this figure for value is of interest as a small beginning in the domestic potash-salts industry, it is practically of no importance in comparison with the total needs of the country, as the quantity it represents is consumed in less than a week in normal times. There was no actual production of potash salts in the United States in 1914. The imports of potash salts (not including kainite and manure salts) for consumption were valued at $3,765,224 in 1915, against $8,743,973 in 1914 and $10,805,720 in 1913.

Pumice.—The production of pumice amounted in 1915 to 27,708 short tons, valued at $63,185, against 27,591 tons, valued at $59,172, in 1914; 24,563 tons, valued at $55,408, in 1913; 27,146 tons, valued at $86,687, in 1912; and 21,689 tons, valued at $88,399, in 1911. The imports for consumption were valued at $65,691 in 1915, $92,668 in 1914, $93,408 in 1913, $74,478 in 1912, and $118,977 in 1911.

Pyrite.—The production of pyrite in 1915 was 394,124 long tons, valued at $1,674,933, against 336,662 tons, valued at $1,283,346, in 1914; 341,338 tons, valued at $1,286,084, in 1913; 350,928 tons, valued at $1,334,259, in 1912; and 301,458 tons, valued at $1,164,871, in 1911. The imports of pyrite (containing not more than 3.5 per cent of copper) for consumption were valued at $4,817,977 in 1915, $4,797,326 in 1914, $3,611,137 in 1913, $3,841,683 in 1912, and $3,788,803 in 1911.

Salt.—The marketed production of salt in 1915 amounted to 38,231,496 barrels (280 pounds net), valued at $11,747,686, compared with 34,804,683 barrels, valued at $10,197,417, in 1914; 34,399,298 barrels, valued at $10,123,139, in 1913; 33,324,808 barrels, valued at $9,402,772, in 1912; and 31,183,968 barrels, valued at $8,345,692, in 1911. The imports for consumption were valued at $366,452 in 1915, against $380,803 in 1914, $421,745 in 1913, and $370,648 in 1912; and the exports at $613,850 in 1915, $586,055 in 1914, $515,194 in 1913, and $418,525 in 1912.

Sand and gravel.—The production of glass sand in 1915 was 1,884,044 short tons, valued at $1,606,640, compared with 1,619,649 tons, valued at $1,568,030, in 1914; 1,791,800 tons, valued at $1,895,991, in 1913; 1,465,386 tons, valued at $1,430,471, in 1912; and 1,538,666 tons, valued at $1,543,733, in 1911. The production of gravel and of sand for molding, building, engine, furnace, and other uses (exclusive of glass sand) was 74,719,259 short tons, valued at $21,514,977, against 77,662,086 tons, valued at $22,278,969, in 1914; 77,764,049 tons, valued at $22,321,517, in 1913; 66,889,175 tons, valued at $21,682,737, in 1912; and 65,308,293 tons, valued at

$19,614,850, in 1911. The imports of sand for consumption were valued at $96,754 in 1915, $139,675 in 1914, $172,257 in 1913, and $141,690 in 1912.

Sand-lime brick.—The production of sand-lime brick was valued at $1,135,104 in 1915, $1,058,512 in 1914, $1,238,325 in 1913, $1,200,223 in 1912, and $897,664 in 1911.

Silica (quartz).—The production of silica (quartz) in 1915 was 112,575 short tons, valued at $273,553, against 153,401 tons, valued at $360,502, in 1914; 97,902 tons, valued at $201,488, in 1913; 97,874 tons, valued at $191,685, in 1912; and 87,943 tons, valued at $155,122, in 1911. The value of the flint and flint pebbles imported for consumption in 1915 was $274.904, against $432,694 in 1914, $324,662 in 1913, $289,904 in 1912, and $236,158 in 1911.

Slate.—The production of slate in 1915 was valued at $4,958,915, against $5,706,787 in 1914, $6,175,476 in 1913, $6,043,318 in 1912, and $5,728,019 in 1911. The imports of slate (in the form of mantels, chimney pieces, roofing slate, slabs, etc.) were valued at $2,768 in 1915, at $4,855 in 1914, and at $5,479 in 1913, and the exports of slate in these years were valued at $46,137, $139,125, and $226,413, respectively.

Sodium nitrate.—There is no domestic production of sodium nitrate. The imports of sodium nitrate for consumption amounted in value to $22,844,746 in 1915, $15,204,539 in 1914, $21,630,811 in 1913, and $16,544,511 in 1912.

Stone.—The value of all kinds of stone produced in the United States in 1915 amounted to $74,595,352, compared with $77,544,103 in 1914, $83,732,995 in 1913, $78,193,220 in 1912, and $77,108,567 in 1911. The imports of stone for consumption were valued in 1915 at $892,668, against $1,389,473 in 1914, $1,615,152 in 1913, and $1,562,231 in 1912. The exports were valued at $1,036,124 in 1915, against $1,363,242 in 1914, $1,856,892 in 1913, and $1,839,878 in 1912. Included under stone is the limestone used for fluxing in blast furnaces, which amounted in 1915 to 18,998,723 long tons, valued at $9,672,347, compared with 15,298,756 tons, valued at $7,890,369, in 1914; 22,620,961 tons, valued at $11,103,989, in 1913; 20,190,554 tons, valued at $9,937,772, in 1912; and 16,126,650 tons, valued at $7,987,208, in 1911.

Sulphur.—The Survey is not at liberty to show the figures for production of sulphur in 1915, this value being included in that for unspecified products. The marketed production of sulphur in 1914 was 327,634 long tons, valued at $5,954,236, against 311,590 tons, valued at $5,479,849, in 1913; 303,472 tons, valued at $5,256,422, in 1912; and 265,664 tons, valued at $4,787,049, in 1911. The imports of sulphur for consumption rose in value from $552,836 in 1911 to $583,974 in 1912, fell to $448,564 in 1913, rose to $477,937 in 1914, and fell to $472,458 in 1915. The exports amounted to 37,312 long tons, valued at $724,679, in 1915, compared with 98,153 tons, valued at $1,807,334, in 1914; 89,221 tons, valued at $1,599,761, in 1913; 57,736 tons, valued at $1,076,414, in 1912; and 28,103 tons, valued at $545,420, in 1911.

Sulphuric acid from copper and zinc smelters.—The statistics of the recovery of sulphuric acid from the gases from copper and zinc smelters were collected by the Survey for the first time in 1911. This production (in terms of 60° Baumé) amounted in 1915 to 904,653

short tons (including 59,189 tons of stronger acid, reported as oleum, etc., and not reduced to 60° Baumé), valued at $7,621,241, compared with 760,638 tons, valued at $5,190,293, in 1914; 632,237 tons, valued at $4,346,272, in 1913; 614,073 tons, valued at $4,240,941, in 1912; and 438,300 tons, valued at $2,733,696, in 1911.

Talc and soapstone.—Exclusive of the production of fibrous talc from Gouverneur, N. Y., the production of talc and soapstone in 1915 amounted to 98,677 short tons, valued at $1,026,739, compared with 86,221 tons, valued at $1,043,801, in 1914; 94,128 tons, valued at $1,119,597, in 1913; 93,413 tons, valued at $1,050,693, in 1912; and 81,521 tons, valued at $1,032,732, in 1911. The imports of talc for consumption were valued at $199,840 in 1915, $177,321 in 1914, $137,680 in 1913, and $122,956 in 1912. In 1915 the production of fibrous talc was 88,214 short tons, valued at $864,843, against 86,075 tons, valued at $821,286, in 1914; 81,705 tons, valued at $788,500, in 1913; 66,867 tons, valued at $656,270, in 1912; and 62,030 tons, valued at $613,286, in 1911.

Thorium minerals (monazite) and zircon.—There has been no production of monazite since 1910, and the gas-mantle industry of the United States has been supplied by imports of monazite from Brazil and of manufactured thorium salts from Germany. The imports of thorium nitrate for consumption were 67,247 pounds, valued at $170,268, in 1915, against 101,927 pounds, valued at $239,376, in 1914; 119,044 pounds, valued at $230,628, in 1913; 117,485 pounds, valued at $225,386, in 1912; and 121,111 pounds, valued at $238,841, in 1911. The imports of monazite and thorium oxide in 1915 were valued at $161,805, compared with $63,282 in 1914, $68,542 in 1913, $47,334 in 1912, and $60,542 in 1911. There has been no production of zircon since 1911, when 3,208 pounds, valued at $802, were reported.

MINERAL PRODUCTS FROM 1880 TO 1915.

From the totals shown in the following tables, "Mineral products of the United States from 1880 to 1915," duplication has been eliminated wherever practicable. For instance, the value of the coke has been excluded from the totals as the value of the coal used in its manufacture enters into the statistics of coal production. In mineral paints, the chemically manufactured pigments (white lead, red lead, lithopone, litharge, and orange mineral), whose aggregate value has exceeded $20,000,000 annually for the last 11 years, are not given in the table, as the base from which they are made is included in the output of lead, whereas the zinc and lead pigments (zinc white or zinc oxide, zinc-lead, leaded zinc oxide, sublimed blue lead, and sublimed white lead) are included, being made directly from the ores and not entering, therefore, into the lead or zinc totals. The value of the pig iron, rather than that of the iron ore, is included in the total, being considered the best means of presenting the statistics of iron in its first marketable condition. Similarly, the value of the products of the clay industries is included as representing the first marketable condition of the greater part of the clay produced. The quantity and value of the clay mined and sold in the raw state by miners to manufacturers of clay are shown separately, but the value is not included in the total.

Mineral products of the United States for the calendar years 1880–1915.

Product.	1880		1881	
	Quantity.	Value.	Quantity.	Value.
Antimonial lead ..... short tons..	2,100	$240,000	2,590	$283,000
Antimony ..... do....	50	[a] 10,000	50	[a] 10,000
Chromic iron ore ..... long tons..	2,288	27,808	2,000	30,000
Copper ..... pounds..	60,480,000	12,942,720	71,680,000	13,045,760
Ferroalloys ..... long tons..	(b)	(b)	(b)	(b)
Gold ..... troy ounces..	1,741,500	36,000,000	1,678,612	34,700,000
Iron:				
Ore ..... long tons..	7,120,362	[a] 23,156,957	7,119,643	(c)
Pig (including ferroalloys) ..... do....	3,375,912	89,315,569	4,144,254	87,029,334
Lead (refined) ..... short tons..	95,725	9,572,500	114,495	10,991,520
Manganese ore ..... long tons..	5,761	86,415	4,895	73,425
Nickel ..... pounds..	233,893	257,282	265,668	292,235
Platinum (crude) ..... troy ounces..	100	400	100	400
Quicksilver ..... flasks..	59,926	1,857,706	60,851	1,815,185
Silver ..... troy ounces..	30,318,700	34,717,000	33,257,800	37,657,500
Titanium ore (rutile) ..... pounds..	100	400	200	700
Zinc ..... short tons..	26,028	2,863,080	33,600	3,494,400
Total value of metallic products	.....	187,880,880	.....	189,413,459
Asbestos ..... short tons..	150	4,312	200	7,000
Asphalt ..... do....	444	4,440	2,000	8,000
Barytes (crude) ..... do....	22,400	80,000	22,400	80,000
Borax (refined) ..... do....	1,846	277,233	2,023	304,461
Bromine ..... pounds..	404,690	114,752	300,000	75,000
Cement ..... barrels..	2,072,943	1,852,707	2,500,000	2,529,000
Clay (potter's) ..... short tons..	28,877	200,457	28,000	200,000
Coal:				
Bituminous ..... do....	42,831,758	53,443,718	53,961,012	60,224,344
Pennsylvania anthracite ..... long tons..	25,580,189	42,196,678	28,500,016	64,125,036
Cobalt oxide ..... pounds..	7,251	24,000	8,280	25,000
Coke ..... short tons..	3,338,300	[a] 6,631,267	4,113,760	[a] 7,725,175
Corundum and emery ..... do....	1,044	29,280	500	80,000
Diatomaceous (infusorial) earth ..... do....	1,833	45,660	1,000	10,000
Feldspar ..... do....	14,000	60,000	15,680	70,000
Fluorspar ..... do....	4,000	16,000	4,000	16,000
Gems and precious stones	.....	100,000	.....	110,000
Graphite ..... pounds..	622,500	49,800	400,000	30,000
Grindstones	.....	500,000	.....	500,000
Gypsum ..... short tons..	90,000	400,000	85,000	350,000
Lime ..... do....	2,800,000	19,000,000	3,000,000	20,000,000
Marls ..... do....	1,000,000	500,000	1,000,000	500,000
Mica (sheet) ..... pounds..	81,669	127,825	100,000	250,000
Millstones	.....	200,000	.....	150,000
Mineral paints:				
Natural pigments ..... short tons..	5,156	145,840	7,840	110,000
Zinc oxide ..... do....	10,107	763,738	10,000	700,000
Mineral waters ..... gallons sold..	2,000,000	500,000	3,700,000	700,000
Oilstones, etc ..... pounds..	420,000	8,000	500,000	8,580
Petroleum ..... barrels..	26,286,123	24,600,638	27,661,238	25,448,339
Phosphate rock ..... long tons..	211,377	1,123,823	266,734	1,980,259
Pyrite ..... do....	2,000	5,000	10,000	60,000
Quartz (flint) ..... short tons..	22,400	80,000	28,000	100,000
Salt ..... barrels..	5,961,060	4,829,566	6,200,000	4,200,000
Slate	.....	1,529,985	.....	1,543,838
Stone	.....	20,626,070	.....	22,556,162
Sulphur ..... long tons..	536	21,000	536	21,000
Talc and soapstone (exclusive of fibrous talc) short tons..	8,441	66,665	7,000	75,000
Talc, fibrous ..... do....	4,210	54,730	5,000	60,000
Total value of nonmetallic products	.....	173,581,917	.....	207,207,019
Unspecified	.....	6,000,000	.....	6,500,000
Grand total	.....	367,462,797	.....	403,120,478

[a] Value not included in total value.
[b] Included under "Pig iron."
[c] Not recorded.

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1882		1883	
	Quantity.	Value.	Quantity.	Value.
Antimonial lead.....short tons..	3,110	$348,000	3,660	$356,000
Antimony.....do....	60	[a] 12,000	60	[a] 12,000
Chromic iron ore.....long tons..	2,500	50,000	3,000	60,000
Copper.....pounds..	90,646,232	17,313,430	115,526,053	19,061,799
Ferroalloys.....long tons..	(b)	(b)	(b)	(b)
Gold.....troy ounces..	1,572,187	32,500,000	1,451,250	30,000,000
Iron:				
Ore.....long tons..	8,700,000	[a] 31,320,000	8,800,000	[a] 26,400,000
Pig (including ferroalloys).....do....	4,623,323	106,336,429	4,595,510	91,910,200
Lead (refined).....short tons..	129,780	12,718,440	140,297	12,065,542
Manganese ore.....long tons..	4,532	67,980	6,155	92,325
Nickel.....pounds..	281,616	309,777	58,800	52,920
Platinum (crude).....troy ounces..	200	600	200	600
Quicksilver.....flasks..	52,732	1,488,624	46,725	1,343,344
Silver.....troy ounces..	36,196,900	41,105,900	35,732,800	39,618,400
Titanium ore (rutile).....pounds..	500	1,800	550	2,000
Zinc.....short tons..	33,765	3,579,090	36,872	3,318,480
Total value of metallic products.....	.....	215,820,070	.....	197,881,610
Asbestos.....short tons..	1,200	36,000	1,000	30,000
Asphalt.....do....	3,000	10,500	3,000	10,500
Barytes (crude).....do....	22,400	80,000	30,240	108,000
Borax (refined).....do....	2,118	338,903	3,250	585,000
Bromine.....pounds..	250,000	75,000	301,100	72,264
Cement.....barrels..	3,250,000	3,672,750	4,190,000	4,293,500
Clay (potter's).....short tons..	33,600	240,000	35,840	250,000
Coal:				
Bituminous.....do....	68,429,933	76,076,487	77,250,680	82,237,800
Pennsylvania anthracite.....long tons..	31,358,264	70,556,094	34,336,469	77,257,055
Cobalt oxide.....pounds..	11,653	32,046	1,096	2,795
Coke.....short tons..	4,793,321	[a] 8,462,167	5,464,721	[a] 8,121,607
Corundum and emery.....do....	500	80,000	550	100,000
Diatomaceous (infusorial) earth.....do....	1,000	8,000	1,000	5,000
Feldspar.....do....	15,680	70,000	15,792	71,112
Fluorspar.....do....	4,000	20,000	4,000	20,000
Gems and precious stones.....	.....	150,000	.....	189,050
Graphite.....pounds..	425,000	34,000	575,000	46,000
Grindstones.....	.....	700,000	.....	600,000
Gypsum.....short tons..	100,000	450,000	90,000	420,000
Lime.....do....	3,100,000	21,700,000	3,200,000	19,200,000
Marls.....do....	1,080,000	540,000	972,000	486,000
Mica (sheet).....pounds..	100,000	250,000	114,000	285,000
Millstones.....	.....	200,000	.....	150,000
Mineral paints:				
Natural pigments.....short tons..	10,080	129,000	10,080	108,000
Zinc oxide.....do....	10,000	700,000	12,000	840,000
Mineral waters.....gallons sold..	5,000,000	800,000	7,529,423	1,119,603
Natural gas.....	.....	215,000	.....	475,000
Oilstones, etc.....pounds..	600,000	10,000	600,000	10,000
Petroleum.....barrels..	30,349,897	23,631,165	23,449,633	25,790,252
Phosphate rock.....long tons..	332,077	1,992,462	378,380	2,270,280
Pyrite.....do....	12,000	72,000	25,000	137,500
Quartz (flint).....short tons..	28,000	100,000	28,000	100,000
Salt.....barrels..	6,412,373	4,320,140	6,192,231	4,251,042
Slate.....	.....	1,753,500	.....	1,898,250
Stone.....	.....	21,556,500	.....	20,008,886
Sulphur.....long tons..	536	21,000	893	27,000
Talc and soapstone (exclusive of fibrous talc).....short tons..	6,000	90,000	8,000	150,000
Talc, fibrous.....do....	6,000	75,000	6,000	75,000
Total value of nonmetallic products.....	.....	230,785,547	.....	243,679,889
Unspecified.....	.....	6,500,000	.....	6,500,000
Grand total.....	.....	453,105,617	.....	448,061,499

[a] Value not included in total value. [b] Included under "Pig iron."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1884		1885	
	Quantity.	Value.	Quantity.	Value.
Aluminum.....pounds..	.....	.....	283	$2,550
Antimonial lead.....short tons..	3,600	$299,000	3,220	291,000
Antimony.....do....	60	[a] 12,000	50	[a] 10,000
Chromic iron ore.....long tons..	2,000	35,000	2,700	40,000
Copper.....pounds..	144,946,653	18,843,065	165,875,483	17,914,552
Ferroalloys.....long tons..	[b]	[b]	[b]	[b]
Gold.....troy ounces..	1,489,950	30,800,000	1,538,373	31,801,000
Iron:				
Ore (including manganiferous ore, 1885) .....long tons..	7,718,129	[a] 21,224,854	7 600,000	[a] 19,000,000
Pig (including ferroalloys).....do....	4,097,868	73,761,624	4,044,526	64,712,400
Lead (refined).....short tons..	136,297	10,085,978	126,192	10,095,360
Manganese ore.....long tons..	10,180	122,160	23,258	190,281
Manganiferous ore.....do....	.....	.....	[c]	[c]
Nickel.....pounds..	64,550	48,412	277,904	179,975
Platinum (crude).....troy ounces..	150	450	250	187
Quicksilver.....flasks..	31,913	973,347	32,073	986,245
Silver.....troy ounces..	37,743,800	41,921,300	39,909,400	42,503,500
Titanium ore (rutile).....pounds..	600	2,000	600	2,000
Zinc.....short tons..	38,544	3,391,872	40,688	3,499,168
Total value of metallic products.....	.....	180,284,208	.....	172,218,218
Asbestos.....short tons..	1,000	30,000	300	9,000
Asphalt.....do....	3,000	10,500	3,000	10,500
Barytes (crude).....do....	28,000	100,000	16,800	75,000
Borax (refined).....do....	3,500	490,000	4,000	480,000
Bromine.....pounds..	281,100	67,464	310,000	89,900
Cement.....barrels..	4,000,000	3,720,000	4,150,000	3,492,500
Clay (all other than brick).....short tons..	39,200	270,000	40,320	275,000
Coal:				
Bituminous.....do....	82,998,704	77,417,066	72,824,321	82,347,648
Pennsylvania anthracite.....long tons..	33,175,756	66,351,512	34,228,548	76,671,948
Cobalt oxide.....pounds..	2,000	5,100	8,423	19,373
Coke.....short tons..	4,873,805	[a] 7,242,878	5,106,696	[a] 7,629,118
Corundum and emery.....do....	600	108,000	600	108,000
Diatomaceous (infusorial) earth.....do....	1,000	5,000	1,000	5,000
Feldspar.....do....	12,208	55,112	15,232	68,000
Fluorspar.....do....	4,000	20,000	5,000	22,500
Gems and precious stones.....	.....	222,975	.....	209,900
Graphite.....pounds..	500,000	35,000	327,883	26,231
Grindstones.....	.....	570,000	.....	500,000
Gypsum.....short tons..	90,000	390,000	90,405	405,000
Lime.....do....	3,700,000	18,500,000	4,000,000	20,000,000
Marls.....do....	875,000	437,500	875,000	437,500
Mica (sheet).....pounds..	147,410	368,525	92,000	161,000
Millstones.....	.....	150,000	.....	100,000
Mineral paints:				
Natural pigments.....short tons..	10,080	104,000	6,636	68,262
Zinc oxide.....do....	13,000	910,000	15,000	1,050,000
Mineral waters.....gallons sold..	10,215,328	1,459,143	9,148,401	1,312,845
Natural gas.....	.....	1,460,000	.....	4,857,200
Oilstones, etc.....pounds..	800,000	12,000	1,000,000	15,000
Petroleum.....barrels..	24,218,438	20,595,966	21,858,785	19,198,243
Phosphate rock.....long tons..	431,779	2,374,784	673,192	4,145,097
Pyrite.....do....	35,000	175,000	49,000	220,500
Quartz (flint).....short tons..	33,600	120,000	33,600	120,000
Salt.....barrels..	6,514,937	4,197,734	7,038,653	4,825,345
Slate.....	.....	1,851,865	.....	1,648,467
Stone.....	.....	18,849,100	.....	19,030,011
Sulphur.....long tons..	446	12,000	638	17,875
Talc and soapstone (exclusive of fibrous talc) short tons..	10,000	200,000	10,000	200,000
Talc, fibrous.....do....	10,000	110,000	10,000	110,000
Total value of nonmetallic products.....	.....	221,755,346	.....	242,332,845
Unspecified.....	.....	5,000,000	.....	5,000,000
Grand total.....	.....	407,039,554	.....	419,551,063

[a] Value not included in total value.
[b] Included under "Pig iron."
[c] Included under "Iron ore."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1886		1887	
	Quantity.	Value.	Quantity.	Value.
Aluminum....pounds..	3,000	$27,000	18,000	$59,000
Antimonial lead....short tons..	3,440	359,000	4,070	416,000
Antimony....do....	35	[a] 7,000	75	[a] 15,000
Chromic iron ore....long tons..	2,000	30,000	3,000	40,000
Copper....pounds..	157,763,043	17,511,698	181,477,331	25,043,872
Ferroalloys....long tons..	(b)	(b)	(b)	(b)
Gold....troy ounces..	1,686,788	34,869,000	1,603,049	33,136,000
Iron:				
Ore(including manganiferous ore)long tons..	10,000,000	[a] 28,000,000	11,300,000	[a] 33,900,000
Pig (including ferroalloys)....do....	5,683,329	95,195,760	6,417,148	121,925,800
Lead (refined)....short tons..	127,189	11,701,388	141,630	12,746,700
Manganese ore....long tons..	30,193	277,636	34,524	333,844
Manganiferous ore....do....	(c)	(c)	(c)	(c)
Nickel....pounds..	214,992	127,157	205,566	133,200
Platinum ((crude)....troy ounces..	50	100	448	1,838
Quicksilver....flasks..	29,981	1,064,325	33,825	1,433,334
Silver....troy ounces..	39,694,000	39,482,400	41,721,600	40,887,200
Titanium ore (rutile)....pounds..	600	2,000	1,000	3,000
Zinc....short tons..	42,641	3,752,408	50,340	4,631,280
Total value of metallic products....	....	204,399,872	....	240,791,068
Asbestos....short tons..	200	6,000	150	4,500
Asphalt....do....	3,500	14,000	4,000	16,000
Barytes (crude)....do....	11,200	50,000	16,800	75,000
Borax (refined)....do....	4,889	488,915	5,500	550,000
Bromine....pounds..	428,334	141,350	199,087	61,717
Cement....barrels..	4,500,000	3,990,000	6,942,744	5,674,377
Clay:				
Brick....	....	6,200,000	....	7,000,000
All other than brick....short tons..	44,800	325,000	48,160	340,000
Coal:				
Bituminous....do....	74,644,981	78,481,056	88,562,314	98,004,656
Pennsylvania anthracite....long tons..	34,853,077	76,119,120	37,578,747	84,552,181
Cobalt oxide....pounds..	8,689	17,378	5,769	10,961
Coke....short tons..	6,845,369	[a] 11,153,366	7,611,705	[a] 15,321,116
Corundum and emery....do....	645	116,190	600	108,000
Diatomaceous (infusorial) earth....do....	1,200	6,000	3,000	15,000
Feldspar....do....	16,688	74,500	11,424	56,100
Fluorspar....do....	5,000	22,000	5,000	20,000
Gems and precious stones....	....	118,510	....	163,600
Graphite....pounds..	415,525	33,242	416,000	34,000
Grindstones....	....	250,000	....	224,400
Gypsum....short tons..	95,250	428,625	95,000	425,000
Lime....do....	4,250,000	21,250,000	4,675,000	23,375,000
Marls....do....	800,000	400,000	600,000	300,000
Mica:				
Scrap....do....	(d)	(d)	(d)	(d)
Sheet....pounds..	40,000	70,000	70,000	142,250
Millstones....	....	140,000	....	100,000
Mineral paints:				
Natural pigments....short tons..	21,056	315,000	24,640	330,000
Zinc oxide....do....	18,000	1,440,000	18,000	1,440,000
Mineral waters....gallons sold..	8,950,317	1,284,070	8,259,609	1,261,463
Natural gas....	....	10,012,000	....	15,817,500
Oilstones, etc....pounds..	1,160,000	15,000	1,200,000	16,000
Petroleum....barrels..	28,064,841	19,996,313	28,283,483	18,877,094
Phosphate rock....long tons..	430,549	1,848,939	480,558	1,836,818
Pyrite....do....	55,000	220,000	52,000	210,000
Quartz (flint)....short tons..	33,600	120,000	35,840	185,000
Salt....barrels..	7,707,081	4,736,585	8,003,962	4,093,846
Slate....	....	1,610,370	....	1,720,317
Stone....	....	20,219,927	....	26,516,200
Sulphur....long tons..	2,232	75,000	2,679	100,000
Talc and soapstone (exclusive of fibrous talc) short tons..	12,000	225,000	12,000	225,000
Talc, fibrous....do....	12,000	125,000	15,000	160,000
Total value of nonmetallic products....	....	250,985,090	....	294,041,980
Unspecified....	....	800,000	....	800,000
Grand total....	....	456,184,962	....	535,633,048

[a] Value not included in total value.
[b] Included under "Pig iron."
[c] Included under "Iron ore."
[d] Value included under "Unspecified."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1888		1889	
	Quantity.	Value.	Quantity.	Value.
Aluminum....pounds..	19,000	$65,000	47,468	$97,335
Antimonial lead....short tons..	4,540	453,000	4,610	461,000
Antimony....do....	100	*a* 20,000	115	*a* 28,000
Bauxite....long tons..	.....	.....	728	2,366
Chromic iron ore....do....	1,500	20,000	2,000	30,000
Copper....pounds..	226,361,466	38,028,726	226,775,962	30,614,755
Ferroalloys....long tons..	(*b*)	(*b*)	(*b*)	(*b*)
Gold....troy ounces..	1,604,478	33,167,500	1,594,775	32,967,000
Iron:				
Ore (including manganiferous ore) long tons.	12,062,530	*a* 28,944,000	14,518,041	*a* 33,351,978
Pig (including ferroalloys)....do....	6,189,738	107,000,000	7,603,642	120,000,000
Lead (refined)....short tons..	147,379	12,969,352	151,787	11,839,386
Manganese ore....long tons..	29,198	279,571	24,197	240,559
Manganiferous ore....do....	(*c*)	(*c*)	(*c*)	(*c*)
Nickel....pounds..	204,328	127,632	252,663	151,598
Platinum (crude)....troy ounces..	500	2,000	500	2,000
Quicksilver....flasks..	33,250	1,370,625	26,484	1,190,970
Silver....troy ounces..	45,792,700	43,045,100	50,094,500	46,838,400
Titanium ore (rutile)....pounds..	1,000	3,000	1,000	3,000
Zinc....short tons..	55,903	5,478,494	58,860	5,886,000
Total value of metallic products....	.....	242,010,000	.....	250,324,369
Asbestos....short tons..	100	3,000	30	1,800
Asphalt....do....	50,472	190,500	51,760	174,037
Barytes (crude)....do....	22,400	110,000	21,460	106,313
Borax (refined)....do....	3,795	455,340	4,000	500,000
Bromine....pounds..	307,386	95,290	418,891	125,667
Cement....barrels..	6,503,295	5,021,139	6,831,876	5,202,951
Clay:				
Brick....	.....	7,500 000	.....	8,000,000
All other than brick....short tons..	41,160	300,000	329,665	635,578
Coal:				
Bituminous....do....	102,040,093	101,860,529	95,682,543	94.504,745
Pennsylvania anthracite....long tons..	41,624,611	89,020,483	40,666,938	65,721,578
Cobalt oxide....pounds..	7,491	15,782	12,955	31,092
Coke....short tons..	8,540,030	*a* 12,445,963	10,258,022	*a* 16,630,301
Corundum and emery....do....	589	91,620	2,245	105,567
Diatomaceous (infusorial) earth....do....	1,500	7,500	3,466	23,372
Feldspar....do....	9,744	50,000	7,806	39,370
Fluorspar....do....	6,000	30,000	9,500	45,835
Gems and precious stones....	.....	139,850	.....	188,807
Graphite....pounds..	400,000	33,000	.....	72,662
Grindstones....	.....	281,800	.....	439,587
Gypsum....short tons..	110,000	550,000	267,769	764,118
Lime....do....	4,908,700	24,543,500	.....	8,217,015
Marls....do....	300,000	150,000	139,522	63,956
Mica:				
Scrap....do....	.....	.....	(*d*)	(*d*)
Sheet....pounds..	48,000	70,000	49,500	50,000
Millstones....	.....	81,000	.....	35,155
Mineral paints:				
Natural pigments....short tons..	29,680	425,000	38,424	483,766
Zinc oxide....do....	20,000	1,600,000	16,970	1,357,600
Mineral waters....gallons sold..	9,578,648	1,679,302	12,780,471	1,748,458
Natural gas....	.....	22,629,875	.....	21,107,099
Oilstones, etc....pounds..	1,500,000	18,000	5,982,000	32,980
Petroleum....barrels..	27,612,025	17,947,620	35,163,513	26,963,340
Phosphate rock....long tons..	451,567	2,039,552	545,745	2,920,276
Pyrite....do....	54,331	167,658	93,705	202,119
Quartz (flint)....short tons..	33,600	175,000	12,447	49,137
Salt....barrels..	8,055,881	4,374,203	8,005,565	4,195,412
Slate....	.....	2,053,440	.....	3,482,513
Stone....	.....	26,719,000	.....	42,925,780
Sulphur....long tons..	.....	.....	402	7,850
Talc and soapstone (exclusive of fibrous talc) short tons..	15,000	250,000	12,715	231,708
Talc, fibrous....do....	20,000	210,000	23,746	244,170
Total value of nonmetallic products....	.....	310,888,983	.....	291,001,413
Unspecified....	.....	900,000	.....	1,000,000
Grand total....	.....	553,798,983	.....	542,325,782

a Value not included in total value.
b Included under "Pig iron."
c Included under "Iron ore."
d Value included under "Unspecified."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1890		1891	
	Quantity.	Value.	Quantity.	Value.
Aluminum.....pounds..	61,281	$61,281	150,000	$100,000
Antimonial lead.....short tons..	3,910	394,000	4,043	381,000
Antimony.....do....	938	[a] 177,508	1,289	[a] 217,957
Bauxite.....long tons..	1,844	6,012	3,593	11,675
Chromic iron ore.....do....	3,599	53,985	1,372	20,580
Copper.....pounds..	259,763,092	40,523,042	284,121,764	36,367,586
Ferroalloys.....long tons..	[b]	[b]	[b]	[b]
Gold.....troy ounces..	1,588,877	32,845,000	1,604,840	33,175,000
Iron:				
Ore(including manganiferous ore).long tons..	16,036,043	[c]	14,591,178	[c]
Pig (including ferroalloys).....do....	9,202,703	151,200,410	8,279,870	128,337,985
Lead (refined).....short tons..	139,720	12,574,800	174,511	15,007,946
Manganese ore.....long tons..	19,287	193,462	22,452	231,909
Manganiferous ore.....do....	[d]	[d]	[d]	[d]
Nickel.....pounds..	223,488	134,093	118,498	71,099
Platinum (crude).....troy ounces..	600	2,500	100	500
Quicksilver.....flasks..	22,926	1,203,615	22,904	1,036,406
Silver.....troy ounces..	54,516,300	57,242,100	58,330,000	57,630,000
Tin (metallic equivalent).....pounds..			125,289	25,058
Titanium ore (rutile).....do....	400	1,000	300	800
Zinc.....short tons..	63,683	7,005,130	80,873	8,087,300
Total value of metallic products.....		303,440,430		280,484,844
Asbestos.....short tons..	71	4,560	66	3,960
Asphalt.....do....	41,016	216,666	45,079	249,264
Barytes (crude).....do....	21,911	86,505	31,069	118,363
Borax (refined).....do....	4,750	617,500	6,690	869,700
Bromine.....pounds..	387,847	104,719	343,000	54,880
Cement.....barrels..	7,776,616	4,526,551	8,222,792	4,638,826
Clay:				
Brick.....		8,500,000		9,000,000
All other than brick.....short tons..	392,000	756,000	448,000	900,000
Coal:				
Bituminous.....do....	111,302,322	110,420,801	117,901,238	117,188,400
Pennsylvania anthracite.....long tons..	41,489,858	66,383,772	45,236,992	73,944,735
Cobalt oxide.....pounds..	6,788	16,291	7,200	18,000
Coke.....short tons..	11 508,021	[a] 23,215,302	10,352,688	[a] 20,393,216
Corundum and emery.....do....	1,970	89,395	2,247	90,230
Diatomaceous (infusorial) earth.....do....	2,532	50,240		21,988
Feldspar.....do....	8,960	45,200	11,200	50,000
Fluorspar.....do....	8,250	55,328	10,044	78,330
Gems and precious stones.....		118,833		235,300
Graphite.....pounds..		77,500	1,559,674	110,000
Grindstones.....		450,000		476,113
Gypsum.....short tons..	182,995	574,523	208,126	628,051
Lime.....do....	[e]	[e]	[e]	[e]
Magnesite (crude).....do....			439	4,390
Marls.....do....	153,620	69,880	135,000	67,500
Mica:				
Scrap.....do....	[f]	[f]		
Sheet.....pounds..	60,000	75,000	75,000	100,000
Millstones.....		23,720		16,587
Mineral paints:				
Natural pigments.....short tons..	43,972	597,892	45,676	588,278
Zinc oxide.....do....	[c]	1,600,000	23,700	1,600,000
Mineral waters.....gallons sold..	13,907,418	2,600,750	18,392,732	2,996,259
Natural gas.....		18,792,725		15,500,084
Oilstones, etc.....		69,909		150,000
Petroleum.....barrels..	45,823,572	35,365,105	54,292,655	30,526,553
Phosphate rock.....long tons..	510,499	3,213,795	587,988	3,651,151
Pyrite.....do....	99,854	273,745	106,536	338,880
Quartz (flint).....short tons..	14,560	57,400	16,800	60,000
Salt.....barrels..	8,876,991	4,752,286	9,987,945	4,716,121
Slate.....				3,825,746
Stone (including lime).....		49,760,811		45,769,000
Sulphur.....long tons..			1,071	39,600
Talc and soapstone (exclusive of fibrous talc) short tons..	13,670	252,309	16,514	243,981
Talc, fibrous.....do....	41,354	389,196	53,054	493,068
Total value of nonmetallic products.....		310,988,907		319,363,338
Unspecified.....		1,000,000		1,000,000
Grand total.....		615,429,337		600,848,182

[a] Value not included in total value.
[b] Included under "Pig iron."
[c] Not recorded.
[d] Included under "Iron ore."
[e] Included under "Stone."
[f] Value included under "Unspecified."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1892		1893	
	Quantity.	Value.	Quantity.	Value.
Aluminum....pounds..	259,885	$172,824	333,629	$266,903
Antimonial lead....short tons..	5,039	446,000	5,013	430,000
Antimony....do....	1,790	[a] 276,416	1,503	[a] 270,540
Bauxite....long tons..	10,518	34,183	9,179	29,507
Chromic iron ore....do....	1,500	25,000	1,450	21,750
Copper....pounds..	344,998,679	40,019,847	329,354,398	35,570,275
Ferroalloys....long tons..	[b]	[b]	[b]	[b]
Gold....troy ounces..	1,597,098	33,015,000	1,739,323	35,955,000
Iron.				
Ore (including manganiferous ore) long tons.	16,296,666	[a] 33,204,896	11,587,629	[a] 19,265,973
Pig (including ferroalloys)....do....	9,157,000	131,161,039	7,124,502	84,810,426
Lead (refined)....short tons..	168,266	13,797,812	158,969	11,763,706
Manganese ore....long tons..	13,613	129,586	7,718	66,614
Manganiferous ore....do....	[c]	[c]	[c]	[c]
Nickel....pounds..	92,252	50,739	49,399	22,197
Platinum (crude)....troy ounces..	80	550	75	517
Quicksilver....flasks..	27,993	1,139,595	30,164	1,108,527
Silver....troy ounces..	63,500,000	55,662,500	60,000,000	46,800,000
Tin (metallic equivalent)....pounds..	162,000	32,400	8,938	1,788
Titanium ore (rutile)....do....	100	300	.....	.....
Zinc....short tons..	87,260	8,027,920	78,832	6,306,560
Total value of metallic products....	.....	283,715,295	.....	223,153,770
Asbestos....short tons..	104	6,416	50	2,500
Asphalt....do....	87,710	453,375	47,779	372,232
Barytes (crude)....do....	32,108	130,025	28,970	88,506
Borax (refined)....do....	6,750	900,000	4,350	652,425
Bromine....pounds..	379,480	64,502	348,399	104,520
Cement....barrels..	8,758,621	5,144,055	8,002,467	4,409,895
Clay:				
Brick....	.....	9,000,000	.....	9,000,000
All other than brick....short tons..	470,400	1,000,000	448,000	900,000
Coal:				
Bituminous....do....	126,856,567	125,124,381	128,385,231	122,751,618
Pennsylvania anthracite....long tons..	46,850,450	82,442,000	48,185,306	85,687,078
Cobalt oxide....pounds..	7,869	15,738	8,422	10,346
Coke....short tons..	12,010,829	[a] 23,536,141	9,477,580	[a] 16,523,714
Corundum and emery....do....	1,771	181,300	1,713	142,325
Diatomaceous (infusorial) earth....	.....	43,655	.....	22,582
Feldspar....short tons..	16,800	75,000	20,578	68,307
Fluorspar....do....	12,250	89,000	12,400	84,000
Gems and precious stones....	.....	312,050	.....	264,041
Graphite....pounds..	1,398,365	87,902	843,103	63,232
Grindstones....	.....	272,244	.....	338,787
Gypsum....short tons..	256,259	695,492	253,615	696,615
Lime....	.....	[d]	.....	[d]
Magnesite (crude)....short tons..	1,004	10,040	704	7,040
Marls....do....	125,000	65,000	75,000	40,000
Mica:				
Scrap....do....	.....	.....	156	8,309
Sheet....pounds..	75,000	100,000	51,111	80,620
Millstones....	.....	23,417	.....	16,639
Mineral paints:				
Natural pigments....short tons..	44,063	582,063	34,410	465,284
Zinc oxide....do....	27,500	2,200,000	24,059	1,804,420
Mineral waters....gallons sold..	21,876,604	4,905,970	23,544,495	4,246,734
Natural gas....	.....	14,870,714	.....	14,346,250
Oilstones, etc....	.....	146,730	.....	135,173
Petroleum....barrels..	50,514,657	25,906,463	48,431,066	28,950,326
Phosphate rock....long tons..	681,571	3,296,127	941,368	4,136,070
Pyrite....do....	109,788	305,191	75,777	256,552
Quartz (flint)....short tons..	22,400	80,000	33,231	63,792
Salt....barrels..	11,698,890	5,654,915	11,897,208	4,154,668
Slate....	.....	4,117,125	.....	2,523,173
Stone (including lime)....	.....	48,224,980	.....	33,737,233
Sulphur....long tons..	2,400	80,640	1,071	42,000
Talc and soapstone (exclusive of fibrous talc) short tons..	23,908	437,449	21,071	255,067
Talc, fibrous....do....	41,925	472,485	35,861	403,436
Thorium minerals (monazite)....pounds..	.....	.....	130,000	7,600
Total value of nonmetallic products....	.....	337,516,444	.....	321,339,395
Unspecified....	.....	1,000,000	.....	1,000,000
Grand total....	.....	622,231,739	.....	545,493,165

[a] Value not included in total value.
[b] Included under "Pig iron."
[c] Included under "Iron ore."
[d] Included under "Stone."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1894		1895	
	Quantity.	Value.	Quantity.	Value.
Aluminum....pounds..	550,000	$316,250	920,000	$464,600
Antimonial lead....short tons..	5,440	430,000	6,060	441,006
Antimony....do....	1,387	[a] 249,706	2,013	[a] 304,169
Bauxite....long tons..	11,066	35,818	17,069	44,000
Chromic iron ore....do....	3,680	53,231	1,740	16,795
Copper....pounds..	354,188,374	33,647,896	380,613,404	40,725,634
Ferroalloys....long tons..	[b]	[b]	[b]	[b]
Gold....troy ounces..	1,910,813	39,500,000	2,254,760	46,610,000
Iron:				
Ore (including manganiferous ore) long tons.	11,879,679	[a] 13,577,325	15,957,614	[a] 18,219,684
Pig (including ferroalloys)....do....	6,657,388	65,007,247	9,446,308	105,198,550
Lead (refined)....short tons..	153,911	10,158,126	159,649	10,217,536
Manganese ore....long tons..	6,308	53,635	9,547	71,769
Manganiferous ore....do....	[c]	[c]	[c]	[c]
Nickel....pounds..	9,616	3,269	10,302	3,091
Platinum (crude)....troy ounces..	100	600	150	900
Quicksilver....flasks..	30,416	933,771	36,067	1,335,922
Silver....troy ounces..	49,500,000	31,422,100	55,727,000	36,445,500
Tin....				
Titanium ore (rutile)....pounds..	150	450	100	350
Zinc....short tons..	75,328	5,272,960	89,686	6,457,392
Total value of metallic products....		186,835,353		248,033,039
Asbestos....short tons..	325	4,463	795	13,525
Asphalt....do....	60,570	353,400	68,163	348,281
Barytes (crude)....do....	23,335	86,983	21,529	68,321
Borax (refined)....do....	7,340	974,445	5,959	595,900
Bromine....pounds..	379,444	102,450	517,421	134,343
Cement....barrels..	8,362,245	5,019,204	8,731,401	5,482,254
Clay products....		64,655,385		65,409,806
Coal:				
Bituminous....short tons..	118,820,405	107,653,501	135,118,193	115,779,771
Pennsylvania anthracite....long tons..	46,358,144	78,488,063	51,785,122	82,019,272
Cobalt oxide....pounds..	6,763	10,145	14,458	20,675
Coke....short tons..	9,203,632	[a] 12,328,856	13,333,714	[a] 19,234,319
Corundum and emery....do....	1,495	95,936	2,102	106,256
Diatomaceous (infusorial) earth....do....	2,584	11,718	4,954	20,514
Feldspar....do....	19,264	167,000	8,523	30,000
Fluorspar....do....	7,500	47,500	4,000	24,000
Fuller's earth....do....			6,900	41,400
Garnet for abrasive purposes....do....	2,401	90,660	3,325	95,050
Gems and precious stones....		108,650		113,621
Graphite....pounds..	918,000	64,010		52,582
Grindstones....		223,214		205,768
Gypsum....short tons..	239,312	761,719	265,503	797,447
Lime....		8,287,821		6,588,822
Magnesite (crude)....short tons..	1,440	10,240	2,220	17,000
Marls....do....	75,000	40,000	60,000	30,000
Mica:				
Scrap....do....	191	8,595	148	5,450
Sheet....pounds..	35,943	43,793	84,408	50,381
Millstones....		13,887		22,542
Mineral paints:				
Natural pigments....short tons..	38,868	424,268	45,830	515,452
Zinc oxide....do....	19,987	1,399,090	20,710	1,449,700
Mineral waters....gallons sold..	21,649,608	3,741,846	21,463,543	4,254,237
Natural gas....		13,954,400		13,006,650
Oilstones, etc....		136,873		155,881
Petroleum....barrels..	49,344,516	35,522,065	52,892,276	57,632,296
Phosphate rock....long tons..	996,949	3,479,547	1,038,551	3,606,094
Pyrite....do....	105,940	363,134	99,549	322,845
Quartz:				
Crystalline....short tons..	6,024	18,054	9,000	27,000
Flint....do....	42,560	319,200	13,747	21,038
Salt....barrels..	12,968,417	4,739,285	13,669,649	4,423,084
Slate....		2,790,324		2,698,700
Stone....		27,305,918		26,655,583
Sulphur....long tons..	446	20,000	1,607	42,000
Talc and soapstone (exclusive of fibrous talc) short tons..	23,144	401,325	21,495	266,495
Talc, fibrous....do....	39,906	435,060	39,240	370,897
Thorium minerals (monazite)....pounds..	546,855	36,193	1,573,000	137,150
Total value of nonmetallic products....		362,409,394		393,658,083
Unspecified....		1,000,000		1,000,000
Grand total....		550,244,747		642,691,122

[a] Value not included in total value. [b] Included under "Pig iron." [c] Included under "Iron ore."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1896		1897	
	Quantity.	Value.	Quantity.	Value.
Aluminum ..... pounds..	1,300,000	$520,000	4,000,000	$1,500,000
Antimonial lead ..... short tons..	7,507	508,000	8,867	696,000
Antimony ..... do....	2,478	[a] 347,539	3,061	[a] 442,300
Bauxite ..... long tons..	18,364	47,338	20,590	57,652
Chromic iron ore ..... do....	786	6,667	.....	.....
Copper ..... pounds..	460,061,430	49,686,634	494,078,274	59,289,393
Ferroalloys ..... long tons..	(b)	(b)	(b)	(b)
Gold ..... troy ounces..	2,568,132	53,088,000	2,774,935	57,363,000
Iron:				
Ore (including manganiferous ore) long tons.	16,005,449	[a] 22,788,069	17,518,046	[a] 18,953,221
Pig (including ferroalloys) ..... do....	8,623,127	90,250,000	9,652,680	95,122,209
Lead (refined) ..... short tons..	179,749	10,784,940	198,498	14,201,856
Manganese ore ..... long tons..	10,088	90,727	11,108	95,505
Manganiferous ore ..... do....	(c)	(c)	(c)	(c)
Nickel ..... pounds..	17,170	4,464	23,707	7,823
Platinum (crude) ..... troy ounces..	163	944	150	900
Quicksilver ..... flasks..	30,765	1,075,544	26,691	995,040
Silver ..... troy ounces..	58,834,800	39,654,600	53,860,000	32,316,000
Tin	.....	.....	.....	.....
Titanium ore (rutile) ..... pounds..	100	350	100	350
Zinc ..... short tons..	81,499	6,356,922	99,980	8,198,360
Total value of metallic products	.....	252,075,130	.....	269,934,178
Asbestos ..... short tons..	504	6,100	580	6,450
Asphalt ..... do....	80,503	577,563	75,945	664,632
Barytes (crude) ..... do....	17,068	46,513	26,042	58,295
Borax (refined) ..... do....	6,754	675,400	8,000	1,080,000
Bromine ..... pounds..	546,580	144,501	487,149	129,094
Cement ..... barrels..	9,525,738	6,485,463	11,037,792	8,226,783
Clay:				
Products	.....	63,110,408	.....	62,359,991
Raw ..... short tons..	(d)	(d)	563,115	[a] 978,448
Coal:				
Bituminous ..... do....	137,640,276	114,891,515	147,617,519	119,595,224
Pennsylvania anthracite ..... long tons..	48,523,287	81,748,651	46,974,714	79,301,954
Cobalt oxide ..... pounds..	10,700	15,301	19,520	31,232
Coke ..... short tons..	11,788,773	[a] 21,660,729	13,288,984	[a] 22,102,514
Corundum and emery ..... do....	2,120	113,246	2,165	106,574
Diatomaceous (infusorial) earth and tripoli ..... short tons..	3,846	26,792	3,833	22,835
Feldspar ..... do....	10,203	35,200	12,516	43,100
Fluorspar ..... do....	6,500	52,000	5,062	37,159
Fuller's earth ..... do....	9,872	59,360	17,113	112,272
Garnet for abrasive purposes ..... do....	2,686	68,877	2,554	80,853
Gems and precious stones	.....	97,850	.....	130,675
Graphite:				
Amorphous ..... short tons..	760	48,460	1,070	65,730
Crystalline ..... pounds..	535,858		1,361,706	
Grindstones	.....	326,826	.....	368,058
Gypsum ..... short tons..	224,254	573,344	288,982	755,864
Lime	.....	6,327,000	.....	6,372,759
Magnesite (crude) ..... short tons..	1,500	11,000	1,143	13,671
Marls ..... do....	60,000	30,000	60,000	30,000
Mica:				
Scrap ..... do....	222	1,750	740	14,452
Sheet ..... pounds..	49,156	65,441	82,676	80,774
Millstones	.....	22,567	.....	25,932
Mineral paints:				
Natural pigments ..... short tons..	43,894	459,089	47,308	501,029
Zinc oxide ..... do....	20,000	1,400,000	25,000	1,750,000
Mineral waters ..... gallons sold..	25,795,312	4,136,192	23,255,911	4,599,106
Natural gas	.....	13,002,512	.....	13,826,422
Oilstones, etc	.....	127,098	.....	149,970
Petroleum ..... barrels..	60,960,361	58,518,709	60,475,516	40,874,072
Phosphate rock ..... long tons..	930,779	2,803,372	1,039,345	2,673,202
Pumice ..... short tons..	.....	.....	158	(d)
Pyrite ..... long tons..	115,483	320,163	143,201	391,541
Quartz:				
Crystalline ..... short tons..	6,000	18,000	7,500	22,500
Flint ..... do....	12,458	24,226	13,466	26,227
Salt ..... barrels..	13,850,726	4,040,839	15,973,202	4,920,020
Slate	.....	2,746,205	.....	3,524,614
Stone	.....	23,965,229	.....	26,894,399
Sulphur ..... long tons..	4,696	87,200	2,031	45,590
Talc and soapstone (exclusive of fibrous talc) ..... short tons..	22,183	354,065	21,923	365,629
Talc, fibrous ..... do....	46,089	399,443	57,009	396,936
Thorium minerals (monazite) ..... pounds..	30,000	1,500	44,000	1,980
Total value of nonmetallic products	.....	387,965,870	.....	380,677,600
Unspecified	.....	1,000,000	.....	1,000,000
Grand total	.....	641,041,000	.....	651,611,778

[a] Value not included in total value.
[b] Included under "Pig iron."
[c] Included under "Iron ore."
[d] Not recorded.

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1898		1899	
	Quantity.	Value.	Quantity.	Value.
Aluminum pounds	5,200,000	$1,716,000	6,500,000	$1,716,000
Antimonial lead short tons	8,473	720,000	6,345	645,000
Antimony do	3,238	[a] 532,101	2,861	[a] 559,189
Bauxite long tons	25,149	75,437	35,280	125,598
Chromic iron ore				
Copper pounds	526,512,987	65,287,610	568,666,921	97,242,043
Ferroalloys long tons	[b]	[b]	[b]	[b]
Gold troy ounces	3,118,398	64,463,000	3,437,210	71,053,400
Iron:				
Ore (including manganiferous ore) long tons	19,433,716	[a] 22,060,887	24,683 173	[a] 34 999,077
Pig (including ferroalloys) do	11,773,934	116,557,000	13,620,703	245,172,654
Lead (refined) short tons	202,203	15,367,428	202,121	18,190,890
Manganese ore long tons	15,957	129,185	9,935	82,278
Manganiferous ore do	[c]	[c]	[c]	[c]
Nickel pounds	11,145	3,956	22,541	8,566
Platinum (crude) troy ounces	225	3,375	300	1,800
Quicksilver flasks	31,092	1,188,647	30,454	1,452,656
Silver troy ounces	54,438,000	32,118,400	54,764,500	32,858,700
Tin				
Titanium ore (rutile) pounds	140	700	230	1,030
Zinc short tons	115,399	10,616,708	129,051	14,969,916
Total value of metallic products		308,247,446		483,520,531
Asbestos short tons	605	10,300	681	11,740
Asphalt do	76,337	675,649	75,085	553,904
Barytes (crude) do	31,306	108,339	41,894	139,528
Borax (refined) do	8,000	1,120,000	20,357	1,139,882
Bromine pounds	486,979	126,614	433,004	108,251
Cement barrels	12,344,208	10,057,551	15,855,445	13,157,142
Clay:				
Products		74,487,680		95,797,370
Raw short tons	585,450	[a] 1,384,766	843,279	[a] 1,645,328
Coal:				
Bituminous do	166,593,623	132,608,713	193,323,187	167,952,104
Pennsylvania anthracite long tons	47,663,076	75,414,537	53,944,647	88,142,130
Cobalt oxide pounds	6,247	9,371	10,230	18,512
Coke short tons	16,047,209	[a] 25,586,699	19,668,569	[a] 34,670,417
Corundum and emery do	4,064	275,064	4,900	150,600
Diatomaceous (infusorial) earth and tripoli short tons	2,733	16,691	4,334	37,032
Feldspar do	13,440	32,395	24,202	211,545
Fluorspar do	7,675	63,050	15,900	96,650
Fuller's earth do	14,860	105,500	12,381	79,644
Garnet for abrasive purposes do	2,967	86,850	2,765	98,325
Gems and precious stones		160,920		185,770
Graphite:				
Amorphous short tons	890	75,200	2,324	167,106
Crystalline pounds	2,360,000		2,900,732	
Grindstones and pulpstones		500,388		684,298
Gypsum short tons	291,638	755,280	486,235	1,287,080
Lime		6,886,549		6,983,067
Magnesite (crude) short tons	1,263	19,075	1,280	18,480
Marls do	60,000	30,000	60,000	30,000
Mica, scrap do	3,999	27,564	1,505	30,878
Mica, sheet pounds	129,520	103,534	108,570	70,587
Millstones		25,934		28,115
Mineral paints:				
Natural pigments short tons	48,479	534,345	51,020	517,328
Zinc oxide do	33,000	2,310,000	40,146	3,211,680
Mineral waters gallons sold	28,853,464	8,051,833	39,562,136	6,948,030
Natural gas		15,296,813		20,074,873
Oilstones, etc		180,486		208,283
Petroleum barrels	55,364,233	44,193,359	57,070,850	64,603,904
Phosphate rock long tons	1,308,885	3,453,460	1,515,702	5,084,076
Pumice short tons	600	13,200	400	10,000
Pyrite long tons	193.364	593,801	174,734	543,249
Quartz:				
Crystalline short tons	8,312	23,990	13,600	39,000
Flint do	21,425	42,670	29,852	180,345
Salt barrels	17,612,634	6,212,554	19,708,614	6,867,467
Slate		3,723,540		3,962,733
Stone		28,635,175		35,244,717
Sulphur long tons	1,071	32,960	4,313	107,500
Talc and soapstone (exclusive of fibrous talc) short tons	22,231	287,112	24,765	330,805
Talc, fibrous do	54,356	411,430	54,655	438,150
Thorium minerals (monazite) pounds	250,776	13,542	350,000	20,000
Total value of nonmetallic products		417,794,018		525,571,880
Unspecified		1,000,000		1,000,000
Grand total		727,041,464		1,010,092,411

[a] Value not included in total value. [b] Included under "Pig iron." [c] Included under "Iron ore."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1900		1901	
	Quantity.	Value.	Quantity.	Value.
Aluminum....pounds..	7,150,000	$1,920,000	7,150,000	$2,238,000
Antimonial lead....short tons..	9,996	995,000	10,656	1,065,000
Antimony....do....	4,226	[a] 837,896	2,639	[a] 539,902
Bauxite....long tons....	23,184	89,676	18,905	79,914
Chromic iron ore....do....	140	1,400	368	5,700
Copper....pounds..	606,117,166	100,615,450	602,072,519	100,546,111
Ferroalloys....long tons..	[b]	[b]	[b]	[b]
Gold....troy ounces..	3,829,897	79,171,000	3,805,500	78,666,700
Iron:				
Ore (including manganiferous ore) long tons	27,553,161	[a] 66,590,504	28,887,479	[a] 49,256,245
Pig (including ferroalloys)....do....	13,789,242	259,944,000	15,878,354	242,174,000
Lead (refined)....short tons..	260,918	22,960,784	258,610	22,240,460
Manganese ore....long tons..	11,771	100,289	11,995	116,722
Manganiferous ore....do....	[c]	[c]	[c]	[c]
Nickel....pounds..	9,715	3,886	6,700	3,551
Platinum (crude, 1900; also refined, 1901) troy ounces..	400	2,500	1,408	27,526
Quicksilver....flasks..	28,317	1,272,566	29,727	1,440,570
Silver....troy ounces..	57,647,000	35,741,100	55,214,000	33,128,400
Tin....				
Titanium ore (rutile)....pounds..	300	1,300	44,250	5,710
Tungsten ores....short tons..	46	11,040	179	27,720
Uranium and vanadium minerals....do....	153	[d]	375	[d]
Zinc....do....	123,886	10,901,968	140,822	11,547,404
Total value of metallic products....		513,731,959		493,313,578
Arsenious oxide....short tons..			300	18,000
Asbestos....do....	1,054	16,310	747	13,498
Asphalt....do....	54,389	415,958	63,134	555,335
Barytes (crude)....do....	67,680	188,089	49,070	157,844
Borax (crude and refined)....do....	25,837	1,018,251	23,231	1,012,118
Bromine....pounds..	521,444	140,790	552,043	154,572
Cement....barrels..	17,231,150	13,283,581	20,068,737	15,786,789
Clay:				
Products....		96,212,345		110,211,587
Raw....short tons..	1,221,660	[a] 1,840,377	1,367,170	[a] 2,576,932
Coal:				
Bituminous....do....	212,316,112	220,930,313	225,828,149	236,422,049
Pennsylvania anthracite....long tons..	51,221,353	85,757,851	60,242,560	112,504,020
Cobalt oxide....pounds..	6,471	11,648	13,360	24,048
Coke....short tons..	20,533,348	[a] 47,443,331	21,795,883	[a] 44,445,923
Corundum and emery....do....	4,305	102,715	4,305	146,040
Diatomaceous (infusorial) earth and tripoli short tons..	3,615	24,207	4,020	52,950
Feldspar....do....	24,821	180,971	34,741	220,422
Fluorspar....do....	18,450	94,500	19,586	113,803
Fuller's earth....do....	9,698	67,535	14,112	96,835
Garnet for abrasive purposes....do....	3,185	123,475	4,444	158,100
Gems and precious stones....		233,170		289,050
Graphite:				
Amorphous....short tons..	611	197,579	809	167,714
Crystalline....pounds..	5,507,855		3,967,612	
Grindstones and pulpstones....		710,026		580,703
Gypsum....short tons..	594,462	1,627,263	633,791	1,506,641
Lime....		6,797,496		8,204,054
Lithium minerals....short tons..	520	[d]	1,750	43,200
Magnesite (crude)....do....	2,252	19,333	3,500	10,500
Marls....do....	60,000	30,000	99,880	124,880
Mica, scrap....do....	5,497	55,202	2,171	19,719
Mica, sheet....pounds..	456,283	92,758	360,060	98,859
Millstones....		32,858		57,179
Mineral paints:				
Natural pigments....short tons..	57,426	644,089	52,209	636,145
Zinc oxide (also zinc lead, 1901)....do....	48,840	3,667,210	49,000	3,870,000
Mineral waters....gallons sold..	47,558,784	6,245,172	54,733,661	7,443,904
Natural gas....		23,698,674		27,066,077
Oilstones, etc....		174,087		158,300
Petroleum....barrels..	63,620,529	75,989,313	69,389,194	66,417,335
Phosphate rock....long tons..	1,491,216	5,359,248	1,483,723	5,316,403
Pumice....				
Pyrite (including sulphur, 1901)....long tons..	204,615	749,991	241,691	1,257,879
Quartz:				
Crystalline....short tons..	14,461	40,705	14,050	41,500
Flint....do....	32,495	86,351	34,420	149,297
Salt....barrels..	20,869,342	6,944,603	20,566,661	6,617,449
Slate....		4,240,466		4,787,525
Stone....		36,970,777		47,284,183
Sulphur....long tons..	3,147	88,100	[e]	[e]

[a] Value not included in total value.
[b] Included under "Pig iron."
[c] Included under "Iron ore."
[d] Not recorded.
[e] Included under "Pyrite."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1900		1901	
	Quantity.	Value.	Quantity.	Value.
Talc and soapstone (exclusive of fibrous talc) short tons	27,913	$383,541	28,643	$421,888
Talc, fibrous do	63,500	499,500	69,200	483,600
Thorium minerals (monazite) pounds	908,000	48,805	748,736	59,262
Total value of nonmetallic products		594,194,796		660,764,256
Unspecified		1,000,000		1,000,000
Grand total		1,108,926,755		1,155,077,834

Product.	1902		1903	
	Quantity.	Value.	Quantity.	Value.
Aluminum pounds	7,300,000	$2,284,590	7,500,000	$2,284,900
Antimonial lead short tons	9,169	846,000	9,579	895,000
Antimony do	3,561	[a] 634,506	3,128	[a] 548,433
Bauxite long tons	27,322	120,366	48,087	171,306
Chromic iron ore do	315	4,567	150	2,250
Copper pounds	659,508,644	80,460,055	698,044,517	95,632,099
Ferroalloys long tons	[b]	[b]	[b]	[b]
Gold troy ounces	3,870,000	80,000,000	3,560,000	73,591,700
Iron:				
Ore (including manganiferous ore) long tons	35,554,135	[a] 65,412,950	35,019,308	[a] 66,328,415
Pig (including ferroalloys) do	17,821,307	372,775,000	18,009,252	344,350,000
Lead (refined) short tons	267,286	21,917,452	280,615	23,571,660
Manganese ore long tons	7,477	66,911	2,825	25,335
Manganiferous ore do	[c]	[c]	[c]	[c]
Nickel pounds	5,748	2,701	114,200	45,900
Platinum (refined) troy ounces	94	1,874	110	2,080
Quicksilver flasks	34,291	1,481,371	35,634	1,613,864
Silver troy ounces	55,500,000	29,415,000	54,300,000	29,322,000
Tin (concentrates) pounds			38,471	[d]
Titanium ore (rutile)				
Tungsten ores short tons	184	34,040	292	43,639
Uranium and vanadium minerals do	3,810	48,125	30	5,625
Zinc do	156,927	15,064,992	159,219	17,195,652
Total value of metallic products		604,517,044		588,753,010
Arsenious oxide short tons	1,353	81,180	611	36,691
Asbestos do	1,005	16,200	887	16,760
Asphalt do	105,458	765,048	101,255	1,005,446
Barytes (crude) do	61,668	203,154	50,397	152,150
Borax (crude and refined, 1902; crude, 1903) short tons	20,004	2,538,614	34,430	661,400
Bromine pounds	513,893	128,472	598,500	167,580
Cement barrels	25,753,504	25,366,380	29,899,140	31,931,341
Clay:				
Products		122,169,531		131,062,421
Raw short tons	1,455,357	[a] 2,061,072	1,641,835	[a] 2,594,042
Coal:				
Bituminous do	260,216,844	290,858,483	282,749,348	351,687,933
Pennsylvania anthracite long tons	36,940,710	76,173,586	66,613,454	152,036,448
Cobalt oxide pounds	3,730	6,714	120,000	228,000
Coke short tons	25,401,730	[a] 63,339,167	25,274,281	[a] 66,498,664
Corundum and emery do	4,251	104,605	2,542	64,102
Diatomaceous (infusorial) earth and tripoli short tons	5,665	53,244	9,219	76,273
Feldspar do	45,287	250,424	41,891	256,733
Fluorspar do	48,018	271,832	42,523	213,617
Fuller's earth do	11,492	98,144	20,693	190,277
Garnet for abrasive purposes do	3,926	132,820	3,950	132,500
Gems and precious stones		328,450		307,900
Graphite:				
Amorphous short tons	4,739	182,108	16,591	225,554
Crystalline pounds	3,936,824		4,538,155	
Grindstones and pulpstones		667,431		721,446
Gypsum short tons	816,478	2,089,341	1,041,704	3,792,943
Lime		9,335,618		9,255,882
Lithium minerals short tons	1,245	25,750	1,155	23,425
Magnesite (crude) do	2,830	8,490	3,744	10,595
Marls do	12,439	12,741	34,211	22,521

[a] Value not included in total value.
[b] Included under "Pig iron."
[c] Included under "Iron ore."
[d] Not recorded.

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1902		1903	
	Quantity.	Value.	Quantity.	Value.
Mica:				
Scrap.....short tons..	1,400	$35,006	1,659	$25,040
Sheet.....pounds..	373,266	83,843	619,600	118,088
Millstones	.....	59,808	.....	52,552
Mineral paints:				
Natural pigments.....short tons..	60,191	745,227	56,262	500,922
Zinc and lead pigments.....do....	61,378	4,691,110	71,758	5,435,858
Mineral waters.....gallons sold..	63,174,552	8,634,179	40,107,147	6,788,426
Natural gas	.....	30,867,863	.....	35,807,860
Oilstones, etc	.....	221,762	.....	366,857
Petroleum.....barrels..	88,766,916	71,178,910	100,461,337	94,694,050
Phosphate rock.....long tons..	1,490,314	4,693,444	1,581,576	5,319,294
Pumice.....short tons..	700	2,750	885	2,665
Pyrite (including sulphur).....long tons..	207,874	947,089	233,127	1,109,818
Quartz:				
Crystalline.....short tons..	15,104	84,335	8,938	76,908
Flint.....do....	36,365	144,209	55,233	156,947
Salt.....barrels..	23,849,231	5,668,636	18,968,089	5,286,988
Sand (glass).....short tons..	943,135	807,797	823,044	855,828
Sand-lime brick	.....	.....	.....	155,040
Slate	.....	5,696,051	.....	6,256,885
Stone	.....	54,798,682	.....	57,433,141
Sulphur.....long tons..	(a)	(a)	(a)	(a)
Talc and soapstone (exclusive of fibrous talc) short tons..	26,854	525,157	26,671	418,460
Talc, fibrous .....do....	71,100	615,350	60,230	421,600
Thorium minerals (monazite) and zircon pounds..	802,000	64,160	865,000	65,200
Total value of nonmetallic products	.....	722,433,728	.....	905,628,365
Unspecified	.....	1,000,000	.....	1,000,000
Grand total	.....	1,327,950,772	.....	1,495,381,375

Product.	1904		1905	
	Quantity.	Value.	Quantity.	Value.
Aluminum (consumption).....pounds..	8,600,000	$2,477,000	11,347,000	$3,246,300
Antimonial lead.....short tons..	11,001	1,029,000	10,995	1,217,571
Antimony.....do....	3,057	b 505,524	3,240	b 705,787
Bauxite.....long tons..	47,661	235,704	48,129	240,292
Chromic iron ore.....do....	123	1,845	22	375
Copper.....pounds..	812,537,267	104,001,770	888,781,267	138,650,346
Ferroalloys.....long tons..	(c)	(c)	(c)	(c)
Gold.....troy ounces..	3,892,480	80,464,700	4,265,742	88,180,700
Iron:				
Ore(including manganiferous ore),longtons.	27,644,330	b 43,186,741	42,526,133	b 75,165,604
Pig (including ferroalloys) .....do....	16,497,033	233,025,000	22,992,380	382,450,000
Lead (refined).....short tons..	297,602	25,593,772	307,514	28,906,316
Manganese ore.....long tons..	3,146	29,466	4,118	36,214
Manganiferous ore.....do....	(d)	(d)	(d)	(d)
Nickel.....pounds..	24,000	11,400	(e)	(e)
Platinum (refined).....troy ounces..	200	4,160	318	5,320
Quicksilver.....flasks..	35,315	1,536,203	30,534	1,105,941
Silver.....troy ounces..	57,682,800	33,456,000	56,101,600	34,222,000
Tin (concentrates).....pounds..	318,000	(f)	.....	.....
Titanium ore (rutile).....short tons..	44	7,000	(e)	(e)
Tungsten ores.....do....	740	184,000	803	268,676
Uranium and vanadium minerals.....do....	45	10,600	4	375
Zinc.....do....	186,702	19,043,604	203,849	24,054,182
Total value of metallic products	.....	501,114,224	.....	702,584,608
Arsenious oxide.....short tons..	36	2,185	754	35,210
Asbestos.....do....	1,480	25,740	3,109	42,975
Asphalt.....do....	108,572	879,836	115,267	758,153
Barytes (crude).....do....	65,727	174,958	48,235	148,803
Borax (crude).....do....	45,647	698,810	46,334	1,019,154
Bromine.....pounds..	897,100	269,130	1,192,758	178,914
Cement.....barrels..	31,675,257	26,031,920	40,102,308	35,931,533

a Included under "Pyrite."
b Value not included in total value.
c Included under "Pig iron."
d Included under "Iron ore."
e Value included under "Unspecified."
f Not recorded.

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1904		1905	
	Quantity.	Value.	Quantity.	Value.
Clay:				
Products	.....	$131,023,248	.....	$149,697,188
Raw, short tons	1,508,752	[a] 2,320,162	1,806,133	[a] 2,768,006
Coal:				
Bituminous, do	278,659,689	305,397,001	315,062,785	334,658,294
Pennsylvania anthracite, long tons	65,318,490	138,974,020	69,339,152	141,879,000
Cobalt oxide, pounds	22,000	42,600	[b]	[b]
Coke, short tons	23,661,106	[a] 46,144,941	32,231,129	[a] 72,476,196
Corundum and emery, do	1,916	56,985	2,126	61,464
Diatomaceous (infusorial) earth and tripoli, short tons	6,274	44,164	10,977	64,637
Feldspar, do	45,188	266,326	35,419	226,157
Fluorspar, do	36,452	234,755	57,385	362,488
Fuller's earth, do	29,480	168,500	25,178	214,497
Garnet for abrasive purposes, do	3,854	117,581	5,050	148,095
Gems and precious stones	.....	324,300	.....	326,350
Graphite:				
Amorphous, short tons	16,927	82,925	21,953	80,639
Crystalline, pounds	5,681,177	238,447	6,036,567	237,572
Grindstones and pulpstones	.....	881,527	.....	777,606
Gypsum, short tons	940,917	2,784,325	1,043,202	3,029,227
Lime, do	2,707,809	9,951,456	2,984,100	10,941,680
Lithium minerals, do	577	5,155	79	1,412
Magnesite (crude), do	2,850	9,298	3,933	15,221
Marls, do	18,989	13,145	38,026	16,494
Mica, scrap, do	1,096	10,854	1,126	17,856
Mica, sheet, pounds	668,358	109,462	924,875	160,732
Millstones	.....	37,338	.....	37,974
Mineral paints:				
Natural pigments, short tons	52,336	493,434	49,765	490,015
Zinc and lead pigments, do	75,619	5,763,599	82,359	6,727,355
Mineral waters, gallons sold	41,969,145	6,218,873	46,544,361	6,491,251
Natural gas	.....	38,496,760	.....	41,562,855
Oilstones, etc	.....	188,985	.....	244,546
Petroleum, barrels	117,080,960	101,175,455	134,717,580	84,157,399
Phosphate rock, long tons	1,874,428	6,580,875	1,947,190	6,763,403
Pumice, short tons	1,530	5,421	1,832	5,540
Pyrite, long tons	207,081	814,808	253,000	938,492
Salt, barrels	22,030,002	6,021,222	25,966,122	6,095,922
Sand:				
Glass, short tons	858,719	796,492	1,060,334	1,107,730
Molding, building, etc., and gravel, do	9,821,009	4,951,607	22,144,633	10,115,915
Sand-lime brick	.....	463,128	.....	972,064
Silica (quartz), short tons	84,210	175,440	70,184	192,227
Slate	.....	5,617,195	.....	5,496,207
Stone	.....	58,765,715	.....	63,798,748
Sulphur, long tons	127,292	2,663,760	181,677	3,706,560
Talc and soapstone (exclusive of fibrous talc), short tons	27,184	433,331	40,134	637,062
Talc, fibrous, do	64,005	507,400	56,500	445,000
Thorium minerals (monazite), and zircon, pounds	745,999	85,038	1,352,418	163,908
Total value of nonmetallic products	.....	859,074,529	.....	921,181,524
Unspecified	.....	400,000	.....	400,000
Grand total	.....	1,360,588,753	.....	1,624,166,132

Product.	1906		1907	
	Quantity.	Value.	Quantity.	Value.
Aluminum (consumption), pounds	14,910,000	$4,262,286	17,211,000	$4,926,948
Antimonial lead, short tons	10,546	1,720,952	9,910	1,322,985
Antimony, do	1,766	[a] 602,949	1,912	[a] 586,186
Bauxite, long tons	75,332	368,311	97,776	480,330
Cadmium, pounds	.....	.....	14,000	[b]
Chromic iron ore, long tons	107	1,800	290	5,640
Copper, pounds	917,805,682	177,136,497	868,996,491	173,799,300
Ferroalloys, long tons	[c]	[c]	[c]	[c]
Gold, troy ounces	4,565,333	94,373,800	4,374,827	90,435,700
Iron:				
Ore, long tons	47,749,728	[a] 100,597,106	51,720,619	[a] 131,996,147
Pig (including ferroalloys), do	25,307,191	505,700,000	25,781,361	529,958,000

[a] Value not included in total value.
[b] Value included under "Unspecified."
[c] Included under "Pig iron."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1906		1907	
	Quantity.	Value.	Quantity.	Value.
Lead (refined)....short tons..	336,200	$38,326,800	352,381	$37,352,386
Manganese ore....long tons..	6,921	88,132	5,604	63,369
Manganiferous ore....do....	41,300	122,400	103,844	259,473
Nickel....pounds..	(a)	(a)	(a)	(a)
Platinum (refined)....troy ounces..	1,439	45,189	357	10,589
Quicksilver....flasks..	26,083	1,030,279	21,554	853,538
Silver....troy ounces..	56,517,900	38,256,400	56,514,700	37,299,700
Tin (metallic equivalent)....do....	.....	35,600	.....	33,285
Titanium ore (rutile)....short tons..	(a)	(a)	(a)	(a)
Tungsten ores (60 per cent concentrates).do....	928	348,867	1,640	890,048
Uranium and vanadium minerals....do....	(a)	(a)	(a)	(a)
Zinc....do....	199,694	21,362,668	223,745	26,401,910
Total value of metallic products....	.....	886,179,981	.....	904,093,201
Arsenious oxide....short tons..	737	63,460	1,751	163,000
Asbestos....do....	1,695	28,565	653	11,899
Asphalt....do....	138,059	1,290,340	223,861	2,826,489
Barytes (crude)....do....	50,231	160,367	89,621	291,777
Borax (crude)....do....	58,173	1,182,410	52,850	1,121,520
Bromine....pounds..	938,128	165,204	1,000,827	195,281
Cement....barrels..	51,000,445	55,302,277	52,230,342	55,903,851
Clay:				
Products....	.....	161,032,722	.....	158,942,369
Raw....short tons..	2,027,452	b 3,245,256	2,183,679	b 3,448,548
Coal:				
Bituminous....do....	342,874,867	381,162,115	394,759,112	451,214,842
Pennsylvania anthracite....long tons..	63,645,010	131,917,694	76,432,421	163,584,056
Cobalt oxide....pounds..	(a)	(a)	(a)	(a)
Coke....short tons..	36,401,217	b 91,608,034	40,779,564	b 111,539,126
Diatomaceous (infusorial) earth and tripoli short tons..	8,099	72,108	.....	104,406
Emery (also corundum in 1906)....do....	1,160	44,310	1,069	12,294
Feldspar....do....	72,656	401,531	91,799	558,944
Fluorspar....do....	40,796	244,025	49,486	287,342
Fuller's earth....do....	32,040	265,400	32,851	291,773
Garnet for abrasive purposes....do....	4,650	157,000	7,058	211,686
Gems and precious stones....	.....	208,000	.....	471,300
Graphite:				
Amorphous....short tons..	16,853	102,175	26,803	125,821
Crystalline....pounds..	5,887,982	238,064	4,947,840	171,149
Grindstones and pulpstones....	.....	744,894	.....	896,022
Gypsum....short tons..	1,540,585	3,837,975	1,751,748	4,942,264
Lime....do....	3,198,087	12,480,653	3,092,524	12,656,705
Lithium minerals....do....	383	7,411	530	11,000
Magnesite (crude)....do....	7,805	23,415	7,561	22,683
Marls....do....	19,104	7,341	14,091	8,429
Mica:				
Scrap....do....	1,489	22,742	3,025	42,800
Sheet....pounds..	1,423,100	252,248	1,060,182	349,311
Millstones....	.....	48,590	.....	31,741
Mineral paints:				
Natural pigments....short tons..	52,959	526,076	52,139	536,263
Zinc and lead pigments....do....	90,792	7,639,107	95,211	8,939,332
Mineral waters....gallons sold..	48,108,580	8,028,387	52,060,520	7,331,503
Natural gas....	.....	46,873,932	.....	54,222,399
Oilstones, etc....	.....	268,070	.....	264,188
Petroleum....barrels..	126,493,936	92,444,735	166,095,335	120,106,749
Phosphate rock....long tons..	2,080,957	8,579,437	2,265,343	10,653,558
Pumice....short tons..	12,200	16,750	8,112	33,818
Pyrite....long tons..	261,422	931,305	247,387	794,949
Salt....barrels..	28,172,380	6,658,350	29,704,128	7,608,323
Sand:				
Glass....short tons..	1,089,430	1,208,788	1,187,296	1,250,067
Molding, building, etc., and gravel...do....	31,842,572	11,489,420	40,664,622	13,242,002
Sand-lime brick....	.....	1,170,005	.....	1,225,769
Silica (quartz)....short tons..	90,779	364,683	33,192	223,801
Slate....	.....	5,668,346	.....	6,019,220
Stone....	.....	66,378,794	.....	71,105,805
Sulphur....long tons..	294,153	5,096,678	293,106	5,142,850
Talc and soapstone (exclusive of fibrous talc) short tons..	58,972	874,356	72,010	905,047
Talc, fibrous....do....	61,672	557,200	67,800	626,000
Thorium minerals (monazite), and zircon pounds..	847,275	152,560	548,152	65,800
Total value of nonmetallic products....	.....	1,016,390,015	.....	1,165,748,197
Unspecified....	.....	200,000	.....	100,000
Grand total....	.....	1,902,769,996	.....	2,069,941,398

a Value included under "Unspecified." b Value not included in total value.

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1908		1909	
	Quantity.	Value.	Quantity.	Value.
Aluminum (consumption)..pounds..	11,152,000	$2,434,600	34,210,000	$6,575,000
Antimonial lead..short tons..	13.629	1,264,771	12,896	1,231,019
Antimony..do....	2,246	[a] 359,360	2,360	[a] 368,160
Bauxite..long tons..	52,167	263,968	129,101	679,447
Cadmium..pounds..	8,000	[b]	5,300	[b]
Chromic iron ore..long tons..	359	7,230	598	8,300
Copper..pounds..	942,570,721	124,419,335	1,092,951,624	142,083,711
Ferroalloys..long tons..	[c]	[c]	[c]	[c]
Gold..troy ounces..	4,574,340	94,560,000	4,821,701	99,673,400
Iron:				
Ore..long tons..	35,983,336	[a] 81,845,904	51,155,437	[a] 109,964,903
Pig (including ferroalloys)..do....	15,936,018	254,321,000	25,795,471	419,175,000
Lead (refined)..short tons..	311,666	26,179,944	352,839	30,344,154
Manganese ore..long tons..	6,144	62,779	1,544	19,675
Manganiferous ore..do....	55,894	133,104	68,654	215,925
Nickel..pounds..	[b]	[b]	[b]	[b]
Platinum (refined)..troy ounces..	750	14,250	638	15,950
Quicksilver..flasks..	19,752	872,446	21,075	957,859
Silver..troy ounces..	52,440,800	28,050,600	54,721,500	28,455,200
Tin (metallic equivalent).....	.....	.....	.....	17,499
Titanium ore (rutile)..short tons..	.....	.....	.....	10,000
Tungsten ores (60 per cent concentrates)..do....	671	229,955	1,619	614,370
Uranium and vanadium minerals..do....	.....	.....	[b]	[b]
Zinc..do....	190,749	17,930,406	230,225	24,864,300
Total value of metallic products.....	.....	550,744,388	.....	754,940,809
Arsenious oxide..short tons..	[b]	[b]	1,214	52,946
Asbestos..do....	936	19,624	3,085	62,603
Asphalt..do....	198,382	2,057,881	228,655	2,138,273
Barytes (crude)..do....	38,527	120,442	61,945	209,737
Borax (crude)..do....	25,000	975,000	41,434	1,534,365
Bromine..pounds..	760,023	73,783	569,725	57,600
Calcium chloride..short tons..	.....	.....	12,853	63,198
Cement..barrels..	52,910,925	44,477,656	66,689,715	53,610,563
Clay:				
Products.....	.....	133,197,762	.....	166,321,213
Raw..short tons..	1,723,901	[a] 2,599,986	2,159,647	[a] 3,449,707
Coal:				
Bituminous..do....	332,573,944	374,135,268	379,744,257	405,486,777
Pennsylvania anthracite..long tons..	74,347,102	158,178,849	72,384,249	149,181,587
Cobalt oxide..pounds..	[b]	[b]	[b]	[b]
Coke..short tons..	26,033,518	[a] 62,483,983	39,315,065	[a] 89,965,483
Diatomaceous (infusorial) earth and tripoli.....	.....	97,442	.....	122,348
Emery..short tons..	669	8,745	1,580	18,185
Feldspar..do....	70,474	428,553	76,539	424,602
Fluorspar..do....	38,785	225,998	50,742	291,747
Fuller's earth..do....	29,714	278,367	33,486	301,604
Garnet for abrasive purposes..do....	1,996	64,620	2,972	102,315
Gems and precious stones.....	.....	415,063	.....	534,280
Graphite:				
Amorphous..short tons..	1,443	75,250	5,096	32,238
Crystalline..pounds..	2,288,000	132,840	6,294,400	313,271
Grindstones and pulpstones,.....	.....	536,095	.....	804,051
Gypsum..short tons..	1,721,829	4,075,824	2,252,785	5,906,738
Lime..do....	2,766,873	11,091,186	3,484,974	13,846,072
Lithium minerals..do....	203	1,550	[b]	[b]
Magnesite (crude)..do....	6,587	19,761	9,465	37,860
Marls..do....	8,469	4,330	[b]	[b]
Mica:				
Scrap..do....	2,417	33,904	4,090	46,047
Sheet..pounds..	972,964	234,021	1,809,582	234,482
Millstones.....	.....	31,420	.....	35,393
Mineral paints:				
Natural pigments..short tons..	50,403	493,900	60,220	567,028
Zinc and lead pigments..do....	75,133	6,946,283	87,525	7,963,332
Mineral waters..gallons sold..	55,868,820	6,712,680	64,674,486	6,894,134
Natural gas.....	.....	54,640,374	.....	63,206,941
Oilstones, etc.....	.....	217,284	.....	214,019
Peat.....	.....	133,000	.....	127,042
Petroleum..barrels..	178,527,355	129,079,184	183,170,874	128,328,487
Phosphate rock..long tons..	2,386,138	11,399,124	2,338,264	10,796,456
Pumice..short tons..	10,569	39,287	15,103	33,439
Pyrite..long tons..	222,598	857,113	247,070	1,028,157
Salt..barrels..	28,822,062	7,553,632	30,107,646	8,343,831

[a] Value not included in total value.
[b] Value included under "Unspecified."
[c] Included under "Pig iron."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1908		1909	
	Quantity.	Value.	Quantity.	Value.
Sand:				
Glass.....short tons..	1,093,553	$1,134,599	1,104,451	$1,163,375
Molding, building, etc., and gravel...do....	36,122,491	12,135,433	58,461,100	17,173,615
Sand-lime brick	.....	1,029,699	.....	1,150,580
Silica (quartz).....short tons..	47,316	190,157	135,469	249,466
Slate	.....	6,316,817	.....	5,441,418
Stone	.....	65,712,499	.....	71,345,199
Sulphur.....long tons..	369,444	6,668,215	239,312	4,432,066
Talc and soapstone (exclusive of fibrous talc) short tons..	46,615	703,832	81,802	862,002
Talc, fibrous.....do....	70,739	697,390	48,536	359,957
Thorium minerals (monazite), and zircon pounds..	422,646	50,718	543,931	65,282
Total value of nonmetallic products.....	.....	1,043,702,454	.....	1,131,515,921
Unspecified.....	.....	250,000	.....	300,000
Grand total.....	.....	1,594,696,842	.....	1,886,756,730

Product.	1910		1911	
	Quantity.	Value.	Quantity.	Value.
Aluminum (consumption).....pounds..	47,734,000	$8,955,700	46,125,000	$8,084,000
Antimonial lead.....short tons..	14,069	1,338,090	14,078	1,380,556
Antimony.....do....	2,229	[a] 367,337	2,254	[a] 386,786
Bauxite.....long tons..	148,932	716,258	155,618	750,649
Cadmium.....pounds..	4,700	[b]	26,152	[b]
Chromic iron ore.....long tons..	205	2,729	120	1,629
Copper.....pounds..	1,080,159,509	137,180,257	1,097,232,749	137,154,092
Ferroalloys.....long tons..	[c]	[c]	253,375	8,377,832
Gold.....troy ounces..	4,657,018	96,269,100	4,687,053	96,890,000
Iron:				
Ore.....long tons..	56,889,734	[a] 140,735,607	41,092,447	[a] 86,716,575
Pig (including ferroalloys, 1910).....do....	26,674,123	412,162,486	23,257,288	327,334,624
Lead (refined).....short tons..	375,402	33,035,376	391,995	35,279,550
Manganese ore.....long tons..	2,258	22,892	2,457	24,586
Manganiferous ore.....do....	61,101	186,765	44,437	114,918
Nickel.....pounds..	[b]	[b]	890,000	127,000
Platinum (refined).....troy ounces..	773	25,277	940	40,890
Quicksilver.....flasks..	20,601	958,153	21,256	977,989
Silver.....troy ounces..	57,137,900	30,854,500	60,399,400	32,615,700
Tin (metallic equivalent)	.....	23,447	.....	56,635
Titanium ore (rutile).....short tons..	566	44,480	.....	.....
Tungsten ores (60 per cent concentrates) short tons..	1,821	832,992	1,139	407,985
Uranium and vanadium minerals .....do....	[b]	[b]	.....	305,500
Zinc.....do....	252,479	27,267,732	271,621	30,964,794
Total value of metallic products.....	.....	749,876,234	.....	680,888,929
Arsenious oxide.....short tons..	1,497	52,305	3,132	73,408
Asbestos.....do....	3,693	68,357	7,604	119,935
Asphalt.....do....	260,080	3,080,067	364,266	3,991,109
Barytes (crude).....do....	42,975	121,746	38,445	122,792
Borax (crude).....do....	42,357	1,201,842	53,330	1,569,151
Bromine.....pounds..	245,437	31,684	651,541	110,902
Calcium chloride.....short tons..	10,971	74,713	14,606	91,215
Cement.....barrels..	77,785,141	68,752,092	79,547,958	66,705,136
Clay:				
Products	.....	170,115,974	.....	162,236,181
Raw.....short tons..	2,389,229	[a] 3,625,485	2,182,698	[a] 3,480,763
Coal:				
Bituminous.....do....	417,111,142	469,281,719	405,907,059	451,375,819
Pennsylvania anthracite.....long tons..	75,433,246	160,275,302	80,771,488	175,189,392
Cobalt oxide	.....	.....	.....	.....
Coke.....short tons..	41,708,810	[a] 99,742,701	35,551,489	[a] 84,130,849
Diatomaceous (infusorial) earth and tripoli	.....	130,006	.....	147,462
Emery.....short tons..	1,028	15,077	659	6,778
Feldspar.....do....	81,102	502,452	92,700	579,008
Fluorspar.....do....	69,427	430,196	87,048	611,447
Fuller's earth.....do....	32,822	293,709	40,697	383,124

[a] Value not included in total value.
[b] Value included under "Unspecified."
[c] Included under "Pig iron."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1910		1911	
	Quantity.	Value.	Quantity.	Value.
Garnet for abrasive purposes.....short tons..	3,814	$113,574	4,076	$121,748
Gems and precious stones.....	.....	295,797	.....	343,692
Graphite:				
Amorphous.....short tons..	1,407	39,710	1,223	32,415
Crystalline.....pounds..	5,590,592	295,733	4,790,000	256,050
Grindstones and pulpstones.....	.....	796,294	.....	907,316
Gypsum.....short tons..	2,379,057	6,523,029	2,323,970	6,462,035
Lime.....do....	3,505,954	14,088,039	3,392,915	13,689,054
Lithium minerals.....do....	(a)	(a)	(a)	(a)
Magnesite (crude).....do....	12,443	74,658	9,375	75,000
Marls.....do....	(a)	(a)	(a)	(a)
Mica:				
Scrap.....do....	4,065	53,265	3,512	45,550
Sheet.....pounds..	2,476,190	283,832	1,887,201	310,254
Millstones.....	.....	28,217	.....	40,069
Mineral paints:				
Natural pigments.....short tons..	68,623	527,795	62,739	498,821
Zinc and lead pigments.....do....	75,162	6,852,804	80,611	7,343,762
Mineral waters.....gallons sold..	62,030,125	6,357,590	63,788,552	6,837,888
Natural gas.....	.....	70,756,158	.....	74,621,534
Oilstones, etc.....	.....	228,694	.....	214,991
Peat.....	.....	140,209	.....	272,114
Petroleum.....barrels..	209,557,248	127,899,688	220,449,391	134,044,752
Phosphate rock.....long tons..	2,654,988	10,917,000	3,053,279	11,900,693
Pumice.....short tons..	23,271	94,943	21,689	88,399
Pyrite.....long tons..	241,612	977,978	301,458	1,164,871
Salt.....barrels..	30,305,656	7,900,344	31,183,968	8,345,692
Sand:				
Glass.....short tons..	1,461,089	1,516,711	1,538,666	1,543,733
Molding, building, etc., and gravel...do....	67,949,347	19,520,919	65,308,293	19,614,850
Sand-lime brick.....	.....	1,169,153	.....	897,664
Silica (quartz).....short tons..	63,577	193,757	87,943	155,122
Slate,.....	.....	6,236,759	.....	5,728,019
Stone.....	.....	76,520,584	.....	77,108,567
Sulphur.....long tons..	255,534	4,605,112	265,664	4,787,049
Sulphuric acid from smelters.....short tons..	.....	.....	438,300	2,733,696
Talc and soapstone (exclusive of fibrous talc) short tons..	79,006	864,213	81,521	1,032,732
Talc, fibrous.....do....	71,710	723,180	62,030	613,286
Thorium minerals (monazite), and zircon pounds..	99,301	12,006	3,208	802
Total value of nonmetallic products.....	.....	1,241,039,986	.....	1,245,145,079
Unspecified.....	.....	300,000	.....	250,000
Grand total.....	.....	1,991,216,220	.....	1,926,284,008

Product.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Aluminum (consumption).....pounds..	65,607,000	$11,907,000	72,379,000	$13,845,000
Antimonial lead.....short tons..	13,552	1,311,348	16,665	1,591,854
Antimony.....do....	1,949	b 332,889	2,508	b 429,363
Bauxite.....long tons..	159,865	768,932	210,241	997,698
Cadmium.....pounds..	52,508	(a)	54,198	(a)
Chromic iron ore.....long tons..	201	2,753	255	2,854
Copper.....pounds..	1,243,268,720	205,139,338	1,224,484,098	189,795,035
Ferroalloys.....long tons..	328,685	12,223,776	296,207	13,015,362
Gold.....troy ounces..	4,520,717	93,451,500	4,299,784	88,884,400
Iron:				
Ore.....long tons..	57,017,614	b 107,050,153	59,643,098	b 130,905,558
Pig.....do....	30,180,969	420,563,388	30,388,935	458,342,345
Lead (refined).....short tons..	392,517	35,326,530	411,878	36,245,264
Manganese ore.....long tons..	1,664	15,723	4,048	40,480
Manganiferous ore.....do....	51,517	19,942	59,403	25,124
Nickel.....pounds..	(a)	(a)	481,565	79,393
Platinum (refined).....troy ounces..	1,005	45,778	1,034	46,530
Quicksilver.....flasks..	25,064	1,053,941	20,213	813,171
Silver.....troy ounces..	63,766,800	39,197,500	66,801,500	40,348,100
Tin (metallic equivalent).....	.....	124,800	.....	46,699
Titanium ore (rutile).....short tons..	275	27,500	305	49,000

a Value included under "Unspecified." b Value not included in total value.

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1912		1913	
	Quantity.	Value.	Quantity.	Value.
Tungsten ores (60 per cent concentrates) short tons	1,330	$502,158	1,537	$672,118
Uranium and vanadium minerals ....do	(a)	(a)	.....	609,361
Zinc....do	323,907	44,699,166	337,252	37,772,224
Total value of metallic products	.....	866,381,073	.....	883,222,012
Arsenious oxide....short tons	3,141	190,757	2,513	159,236
Asbestos....do	4,403	87,959	1,100	11,000
Asphalt....do	449,510	4,620,731	529,190	5,282,370
Barytes (crude)....do	37,478	153,313	45,298	156,275
Borax (crude)....do	42,315	1,127,813	58,051	1,491,530
Bromine....pounds	647,200	145,805	572,400	115,436
Calcium chloride....short tons	18,550	117,272	19,611	130,030
Cement....barrels	85,925,651	69,554,385	89,541,348	89,550,527
Clay:				
Products	.....	172,811,275	.....	181,289,132
Raw....short tons	2,530,265	b 3,946,020	2,647,989	b 4,180,459
Coal:				
Bituminous....do	450,104,982	517,983,445	478,435,297	565,234,952
Pennsylvania anthracite....long tons	75,322,855	177,622,626	81,718,680	195,181,127
Cobalt oxide	.....	.....	.....	.....
Coke....short tons	43,983,599	b 111,805,113	46,299,530	b 128,922,273
Diatomaceous (infusorial) earth and tripoli	.....	125,446	.....	285,821
Emery....short tons	992	6,652	957	4,785
Feldspar....do	86,572	520,562	120,955	776,551
Fluorspar....do	116,545	769,163	115,580	736,286
Fuller's earth....do	32,715	305,522	38,594	369,750
Garnet for abrasive purposes....do	4,947	163,237	5,308	183,422
Gems and precious stones	.....	319,722	.....	319,454
Graphite:				
Amorphous....short tons	2,063	32,894	2,243	39,428
Crystalline....pounds	3,543,771	187,689	5,064,727	254,328
Grindstones and pulpstones	.....	916,339	.....	855,627
Gypsum....short tons	2,500,757	6,563,908	2,599,508	6,774,822
Lime....do	3,529,462	13,970,114	3,595,390	14,648,362
Lithium minerals....do	(a)	(a)	(a)	(a)
Magnesite (crude)....do	10,512	84,096	9,632	77,056
Marls....do	(a)	(a)	(a)	(a)
Mica:				
Scrap....do	3,226	49,073	5,322	82,543
Sheet....pounds	845,483	282,823	1,700,677	353,517
Millstones	.....	71,414	.....	56,163
Mineral paints:				
Natural pigments....short tons	74,657	561,693	70,595	512,410
Zinc and lead pigments....do	106,497	9,507,895	97,573	9,020,896
Mineral waters....gallons sold	62,281,201	6,615,671	57,867,399	5,631,391
Natural gas	.....	84,563,957	.....	87,846,677
Oilstones, etc	.....	232,218	.....	207,352
Peat	.....	228,572	.....	197,200
Petroleum....barrels	222,935,044	164,213,247	248,446,230	237,121,388
Phosphate rock....long tons	2,973,332	11,675,774	3,111,221	11,796,231
Pumice....short tons	27,146	86,687	24,563	55,408
Pyrite....long tons	350,928	1,334,259	341,338	1,286,084
Salt....barrels	33,324,808	9,402,772	34,399,298	10,123,139
Sand:				
Glass....short tons	1,465,386	1,430,471	1,791,800	1,895,991
Molding, building, etc., and gravel...do	66,889,175	21,682,737	77,764,049	22,321,517
Sand-lime brick	.....	1,200,223	.....	1,238,325
Silica (quartz)....short tons	97,874	191,685	97,902	201,488
Slate	.....	6,043,318	.....	6,175,476
Stone	.....	78,193,220	.....	83,732,995
Sulphur....long tons	303,472	5,256,422	311,590	5,479,849
Sulphuric acid from smelters....short tons	614,073	4,240,941	632,237	4,346,272
Talc and soapstone (exclusive of fibrous talc) short tons	93,413	1,050,693	94,128	1,119,597
Talc (fibrous)....do	66,867	656,270	81,705	788,500
Thorium minerals (monazite), and zircon	.....	.....	.....	.....
Total value of nonmetallic products	.....	1,377,152,760	.....	1,555,517,716
Unspecified	.....	500,000	.....	420,000
Grand total	.....	2,244,033,833	.....	2,439,159,728

a Value included under "Unspecified." b Value not included in total value.

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1914		1915	
	Quantity.	Value.	Quantity.	Value.
Aluminum (consumption)....pounds..	79,129,000	$14,522,700	99,806,000	$17,985,500
Antimonial lead [a]...short tons (2,000 pounds)..	16,667	1,572,167	23,224	3,665,736
Antimony....do....	2,705	[b] 566,490	5,364	[b] 2,373,760
Bauxite....long tons (2,240 pounds)..	219,318	1,069,194	297,041	1,514,834
Cadmium....pounds..	91,409	81,205	91,415	108,443
Chromic iron ore....long tons..	591	8,715	3,281	36,744
Copper [c], value at New York City....pounds..	1,150,137,192	152,968,000	1,388,009,527	242,902,000
Ferroalloys....long tons..	255,524	9,350,245	388,644	17,450,385
Gold [d]....troy ounces..	4,572,976	94,531,800	4,887,602	101,035,700
Iron:				
Ore....long tons..	39,714,280	[e] 71,905,079	55,493,100	[e] 101,288,984
Pig....do....	22,263,263	298,777,429	30,384,486	401,409,604
Lead (refined) [c], value at New York City short tons..	512,794	39,998,009	507,026	47,660,000
Manganese ore....long tons..	2,635	27,377	9,709	113,309
Manganiferous ore [f]....do....	98,235	218,497	185,238	266,380
Nickel [g], value at New York City....pounds..	845,334	313,000	1,120,556	448,222
Platinum and allied metals, value at New York City....troy ounces..	6,324	280,885	8,665	478,688
Quicksilver, value at San Francisco flasks (75 pounds net)..	16,548	811,680	21,033	1,826,912
Silver....troy ounces..	72,455,100	40,067,700	74,921,075	37,397,300
Tin (metallic equivalent)....pounds..	208,000	66,560	204,000	78,846
Titanium ore (rutile)....short tons..	94	11,280	250	27,500
Tungsten ores (60 per cent concentrates) short tons..	990	435,000	2,332	4,100,000
Uranium and vanadium minerals....	....	941,300	....	693,750
Zinc [c], value at St. Louis, 1914; sales value, 1915 short tons..	343,418	35,029,000	458,135	113,617,000
Total value of metallic products....	....	691,081,734	....	992,816,853
Arsenious oxide....short tons..	4,670	313,147	5,498	302,116
Asbestos....do....	1,247	18,965	1,731	76,952
Asphalt....do....	[h] 440,571	[h] 3,659,092	740,254	5,242,073
Barytes (crude)....do....	[h] 52,747	[h] 155,647	108,547	381,032
Borax (crude)....do....	62,400	1,464,400	67,003	1,677,099
Bromine....pounds..	576,991	203,094	855,857	856,307
Calcium chloride....short tons..	19,403	121,766	20,535	130,830
Cement....barrels (380 pounds net)..	87,257,552	80,533,203	87,685,222	75,155,102
Clay:				
Products....	....	164,986,983	....	163,120,232
Raw....short tons..	2,209,860	[e] 3,756,568	2,362,954	[e] 3,971,941
Coal:				
Bituminous [i]....do....	422,703,970	493,309,244	442,624,426	502,037,688
Pennsylvania anthracite....long tons..	81,090,631	188,181,399	79,459,876	184,653,498
Cobalt oxide....	....	....	....	....
Coke....short tons..	34,555,914	[e] 88,334,217	41,581,150	[e] 105,503,868
Diatomaceous (infusorial) earth and tripoli..	....	252,327	....	[j] 611,021
Emery....short tons..	485	2,425	3,063	31,131
Feldspar....do....	135,419	629,873	113,769	629,356
Fluorspar....do....	95,116	570,041	136,941	764,475
Fuller's earth....do....	40,981	403,646	47,901	489,219
Garnet for abrasive purposes....do....	4,231	145,510	4,301	139,584
Gems and precious stones....	....	124,651	....	170,431
Graphite:				
Amorphous....short tons..	1,725	38,750	1,181	12,358
Crystalline....pounds..	5,220,539	285,368	7,074,370	417,273
Grindstones and pulpstones....	....	689,344	....	648,479
Gypsum....short tons..	2,476,465	6,895,989	2,447,611	6,596,893
Lime....do....	3,380,928	[h] 13,268,938	3,589,699	14,336,756

[a] From both domestic and foreign ores.
[b] From all sources. Values excluded from metallic totals, as the values of the antimony contained in antimonial lead are included in the antimonial lead values and the remainder under "Unspecified."
[c] Product from domestic ores only.
[d] Value, $20.671834625323 an ounce.
[e] Value not included in total value.
[f] Exclusive of those ores from Lake Superior district running so low in manganese as to be classed with iron ore.
[g] By-product in electrolytic copper refining.
[h] Revised figures.
[i] Includes brown coal and lignite, and anthracite mined elsewhere than in Pennsylvania.
[j] Exclusive of considerable production for special uses which is included under "Unspecified."

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	Increase or decrease in 1915.		Percentage of increase or decrease in 1915.	
	Quantity.	Value.	Quantity.	Value.
Aluminum (consumption)....pounds..	+ 20,677,000	+ $3,462,800	+ 26	+ 24
Antimonial lead....short tons..	+ 6,557	+ 2,093,569	+ 39	+ 133
Antimony....do....	+ 2,659	+ 1,807,270	+ 98	+ 319
Bauxite....long tons..	+ 77,723	+ 445,640	+ 35	+ 42
Cadmium....pounds..	+ 6	+ 27,238	.....	+ 34
Chromic iron ore....long tons..	+ 2,690	+ 28,029	+ 455	+ 322
Copper....pounds..	+237,872,335	+ 89,934,000	+ 21	+ 59
Ferroalloys....long tons..	+ 133,120	+ 8,100,140	+ 52	+ 87
Gold....troy ounces..	+ 314,626	+ 6,503,900	+ 7	+ 7
Iron:				
Ore....long tons..	+ 15,778,820	+ 29,383,905	+ 40	+ 41
Pig....do....	+ 8,121,223	+102,632,175	+ 36	+ 34
Lead (refined)....short tons..	— 5,768	+ 7,662,000	— 1	+ 19
Manganese ore....long tons..	+ 7,074	+ 85,932	+ 268	+ 314
Manganiferous ore....do....	+ 86,973	+ 47,883	+ 89	+ 22
Nickel....pounds..	+ 275,222	+ 135,222	+ 33	+ 43
Platinum and allied metals....troy ounces..	+ 2,341	+ 197,803	+ 37	+ 70
Quicksilver....flasks..	+ 4,485	+ 1,015,232	+ 27	+ 125
Silver....troy ounces..	+ 2,505,975	— 2,670,400	+ 3	— 7
Tin (metallic equivalent)....pounds..	— 4,000	+ 12,286	— 2	+ 18
Titanium ore (rutile)....short tons..	+ 156	+ 16,220	+ 166	+ 144
Tungsten ores (60 per cent concentrates) short tons..	+ 1,342	+ 3,665,000	+ 136	+ 843
Uranium and vanadium minerals....	.....	— 247,550	.....	— 26
Zinc....short tons..	+ 114,717	+ 78,588,000	+ 33	+ 224
Total value of metallic products....	.....	+301,735,119	.....	+ 44
Arsenious oxide....short tons..	+ 828	— 11,031	+ 18	— 4
Asbestos....do....	+ 484	+ 57,987	+ 39	+ 306
Asphalt....do....	+ 299,683	+ 1,582,981	+ 68	+ 43
Barytes (crude)....do....	+ 55,800	+ 225,385	+106	+ 145
Borax (crude)....do....	+ 4,603	+ 212,699	+ 7	+ 15
Bromine....pounds..	+ 278,866	+ 653,213	+ 48	+ 322
Calcium chloride....short tons..	+ 1,132	+ 9,064	+ 6	+ 7
Cement....barrels..	+ 427,670	— 5,378,101	+ .5	— 7
Clay:				
Products....	.....	— 1,866,751	.....	— 1
Raw....short tons..	+ 153,094	+ 215,373	+ 7	+ 6
Coal:				
Bituminous....do....	+ 19,920,456	+ 8,728,444	+ 5	+ 2
Pennsylvania anthracite....long tons..	— 1,630,755	— 3,527,901	— 2	— 2
Cobalt oxide....	.....	.....	.....	.....
Coke....short tons..	+ 7,025,236	+ 17,169,651	+ 20	+ 19
Diatomaceous (infusorial) earth and tripoli....	.....	+ 358,694	.....	+ 142
Emery....short tons..	+ 2,578	+ 28,706	+532	+1,184
Feldspar....do....	— 21,650	— 517	— 16	— .1
Fluorspar....do....	+ 41,825	+ 194,434	+ 44	+ 34
Fuller's earth....do....	+ 6,920	+ 85,573	+ 17	+ 21
Garnet for abrasive purposes....do....	+ 70	— 5,926	+ 2	— 4
Gems and precious stones....	.....	+ 45,780	.....	+ 37
Graphite:				
Amorphous....short tons..	— 544	— 26,392	— 32	— 68
Crystalline....pounds..	+ 1,853,831	+ 131,905	+ 36	+ 46
Grindstones and pulpstones....	.....	— 40,865	.....	— 6
Gypsum....short tons..	— 28,854	— 299,096	— 1	— 4
Lime....do....	+ 208,771	+ 1,067,818	+ 6	+ 8

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	1914		1915	
	Quantity.	Value.	Quantity.	Value.
Lithium minerals ..... short tons..	(a)	(a)	(a)	(a)
Magnesite (crude) ..... do....	11,293	$124,223	30,499	$274,491
Marls ..... do....	(a)	(a)	(a)	(a)
Mica:				
Scrap ..... do....	3,730	51,416	3,959	50,510
Sheet ..... pounds..	556,933	278,540	553,821	378,259
Millstones	.....	43,316	.....	53,480
Mineral paints:				
Natural pigments [b] ..... short tons..	66,766	[c] 633,390	57,442	551,598
Zinc and lead pigments [b] ..... do....	106,791	9,978,710	141,383	14,962,461
Mineral waters ..... gallons sold..	54,358,466	4,892,328	52,113,503	5,138,794
Natural gas	.....	94,115,524	.....	101,312,381
Oilstones, etc	.....	167,948	.....	115,175
Peat	.....	309,692	.....	288,537
Petroleum ..... barrels (42 gallons)..	265,762,535	214,125,215	281,104,104	179,462,890
Phosphate rock ..... long tons..	2,734,043	9,608,041	1,835,667	5,413,449
Pumice ..... short tons..	27,591	59,172	27,708	63,185
Pyrite ..... long tons..	336,662	1,283,346	394,124	1,674,933
Salt ..... barrels (280 pounds net)..	34,804,683	[c] 10,197,417	38,231,496	11,747,686
Sand:				
Glass ..... short tons..	1,619,649	1,568,030	1,884,044	1,606,640
Molding, building, etc., and gravel .... do....	77,662,086	22,278,969	74,719,259	21,514,977
Sand-lime brick	.....	1,058,512	.....	1,135,104
Silica (quartz) ..... short tons..	153,401	360,502	112,575	273,553
Slate	.....	5,706,787	.....	4,958,915
Stone	.....	[c] 77,544,103	.....	74,595,352
Sulphur ..... long tons..	327,634	5,954,236	(d)	(d)
Sulphuric acid (60° Baumé) from copper and zinc smelters ..... short tons..	760,638	5,190,293	[e] 904,653	7,621,241
Talc and soapstone (exclusive of fibrous talc) short tons..	86,221	1,043,801	98,677	1,026,739
Talc, fibrous ..... do....	86,075	821,286	88,214	864,843
Thorium minerals (monazite), and zircon pounds..	.....	.....	.....	.....
Total value of nonmetallic products	.....	1,423,648,599	.....	1,393,565,098
Unspecified [f]	.....	470,000	.....	[f] 7,450,000
Grand total	.....	2,115,200,333	.....	2,393,831,951

Product.	Increase or decrease in 1915.		Percentage of increase or decrease in 1915.	
	Quantity.	Value.	Quantity.	Value.
Lithium minerals ..... short tons..	.....	.....	.....	.....
Magnesite (crude) ..... do....	+ 19,206	+ $150,268	+170	+121
Marls ..... do....	.....	.....	.....	.....
Mica:				
Scrap ..... do....	+ 229	− 906	+ 6	− 2
Sheet ..... pounds..	− 3,112	+ 99,719	− .6	+ 36
Millstones	.....	+ 10,164	.....	+ 23
Mineral paints:				
Natural pigments ..... short tons..	− 9,324	− 81,792	− 14	− 13
Zinc and lead pigments ..... do....	+ 34,592	+ 4,983,751	+ 32	+ 50
Mineral waters ..... gallons sold..	− 2,244,963	+ 246,466	− 4	+ 5
Natural gas	.....	+ 7,196,857	.....	+ 8
Oilstones, etc	.....	− 52,773	.....	− 31
Peat	.....	− 21,155	.....	− 7
Petroleum ..... barrels..	+15,341,569	−34,662,325	+ 6	− 16
Phosphate rock ..... long tons..	− 898,376	− 4,194,592	− 33	− 44
Pumice ..... short tons..	+ 117	+ 4,013	+ .4	+ 7
Pyrite ..... long tons..	+ 57,462	+ 391,587	+ 17	+ 31
Salt ..... barrels..	+ 3,426,813	+1,550,269	+ 10	+ 15

[a] Value included under "Unspecified."

[b] Natural pigments: Ocher, umber, sienna, metallic paint, mortar colors, and ground slate and shale Zinc and lead pigments: Sublimed blue lead, sublimed white lead, leaded zinc oxide, zinc oxide, and zinc lead

[c] Revised figures.

[d] Value included under "Unspecified."

[e] Includes 59,189 tons of stronger acid, reported as oleum, etc., not converted to 60° Baumé.

[f] Includes in 1915 antimony other than content of antimonial lead, bismuth, cadmium sulphide, diatomaceous earth for special uses, lithium minerals, magnesium, marls, molybdenum, nickel content of hydrous nickel sulphate, potash salts, selenium, silica sand and sandstone (finely ground), sulphur, and an estimate of the value of miscellaneous mineral products not collected annually by the Survey.

Mineral products of the United States for the calendar years 1880–1915—Continued.

Product.	Increase or decrease in 1915.		Percentage of increase or decrease in 1915.	
	Quantity.	Value.	Quantity.	Value.
Sand:				
Glass.....short tons..	+ 264,395	+ $38,610	+16	+ 2
Molding, building, etc., and gravel....do....	−2,942,827	− 763,992	− 4	− 3
Sand-lime brick.....	.....	+ 76,592	.....	+ 7
Silica (quartz).....short tons..	− 40,826	− 86,949	−27	−24
Slate.....	.....	− 747,872	.....	−13
Stone.....	.....	− 2,948,751	.....	− 4
Sulphur.....long tons..	.....	.....	.....	.....
Sulphuric acid (60° Baumé) from copper and zinc smelters.....short tons..	+ 144,015	+ 2,430,948	+19	+47
Talc and soapstone (exclusive of fibrous talc) short tons..	+ 12,456	− 17,062	+14	− 2
Talc, fibrous.....do....	+ 2,139	+ 43,557	+ 2	+ 5
Thorium minerals (monazite), and zircon pounds..	.....	.....	.....	.....
Total value of nonmetallic products.....	.....	− 30,083,501	.....	− 2
Unspecified.....	.....	.....	.....	.....
Grand total.....	.....	+278,631,618	.....	+13

Total value of mineral products of the United States from 1880 to 1915.

Year.	Metallic.	Nonmetallic.	Unspecified (metallic and nonmetallic).	Total.
1880.....	$187,880,880	$173,581,917	$6,000,000	$367,462,797
1881.....	189,413,459	207,207,019	6,500,000	403,120,478
1882.....	215,820,070	230,785,547	6,500,000	453,105,617
1883.....	197,881,610	243,679,889	6,500,000	448,061,499
1884.....	180,284,208	221,755,346	5,000,000	407,039,554
1885.....	172,218,218	242,332,845	5,000,000	419,551,063
1886.....	204,399,872	250,985,090	800,000	456,184,962
1887.....	240,791,068	294,041,980	800,000	535,633,048
1888.....	242,010,000	310,888,983	900,000	553,798,983
1889.....	250,324,369	291,001,413	1,000,000	542,325,782
1890.....	303,440,430	310,988,907	1,000,000	615,429,337
1891.....	280,484,844	319,363,338	1,000,000	600,848,182
1892.....	283,715,295	337,516,444	1,000,000	622,231,739
1893.....	223,153,770	321,339,395	1,000,000	545,493,165
1894.....	186,835,353	362,409,394	1,000,000	550,244,747
1895.....	248,033,039	393,658,083	1,000,000	642,691,122
1896.....	252,075,130	387,965,870	1,000,000	641,041,000
1897.....	269,934,178	380,677,600	1,000,000	651,611,778
1898.....	308,247,446	417,794,018	1,000,000	727,041,464
1899.....	483,520,531	525,571,880	1,000,000	1,010,092,411
1900.....	513,731,959	594,194,796	1,000,000	1,108,926,755
1901.....	493,313,578	660,764,256	1,000,000	1,155,077,834
1902.....	604,517,044	722,433,728	1,000,000	1,327,950,772
1903.....	588,753,010	905,628,365	1,000,000	1,495,381,375
1904.....	501,114,224	859,074,529	400,000	1,360,588,753
1905.....	702,584,608	921,181,524	400,000	1,624,166,132
1906.....	886,179,981	1,016,390,015	200,000	1,902,769,996
1907.....	904,093,201	1,165,748,197	100,000	2,069,941,398
1908.....	550,744,388	1,043,702,454	250,000	1,594,696,842
1909.....	754,940,809	1,131,515,921	300,000	1,886,756,730
1910.....	749,876,234	1,241,039,986	300,000	1,991,216,220
1911.....	680,888,929	1,245,145,079	250,000	1,926,284,008
1912.....	866,381,073	1,377,152,760	500,000	2,244,033,833
1913.....	883,222,012	1,555,517,716	420,000	2,439,159,728
1914.....	691,081,734	1,423,648,599	470,000	2,115,200,323
1915.....	992,816,853	1,393,565,098	7,450,000	2,393,831,951
Grand total.....	16,284,703,407	23,480,247,981	64,040,000	39,828,991,388

FIGURE A.—Curves showing value of mineral products of the United States, 1880–1915.

IMPORTS AND EXPORTS.[1]

Value of imports for consumption and of exports of mineral products in the calendar years 1914 and 1915.

Metallic Products.

Product.	1914	1915
IMPORTS.		
Aluminum salts	$73,028	$34,322
Antimony (crude and ore)	75,345	332,130
Antimony (metal or regulus)	736,420	2,660,895
Antimony (oxide and salts of)	315,001	132,193
Bauxite	96,500	17,107
Bismuth	165,208	108,288
Brass, old, fit only for remanufacture	488,803	1,809,827
Cadmium	368	284
Chromic iron ore	695,645	780,061
Chromium salts	3,972	3,657
Cobalt (oxide ore and zaffer)	274,538	219,111
Copper in ore, matte, ingots, bars, manufactures	39,491,973	44,410,965
Ferroalloys:		
Ferrochrome (and chromium)	21,553	1,662
Ferromanganese (and manganese)	3,619,607	3,333,699
Ferromolybdenum (and molybdenum)	59	203
Ferrophosphorus	1,136	617
Ferrosilicon	341,925	311,219
Ferrotitanium (and titanium)	8,356	.....
Ferrotungsten (and tungsten)	222,447	9,588
Ferrovanadium	.....	.....
Spiegeleisen	71,147	5,110
Iron ore	4,482,242	4,181,645
Lead, in ore, base bullion, pigs, sheets, etc	504,978	772,955
Manganese ore	2,024,120	2,055,980
Nickel, in ore, matte, oxide, etc	5,028,818	7,629,686
Platinum and allied metals:		
Ore	72,260	112,387
Platinum	2,908,353	2,302,888
Iridium, osmium, palladium, rhodium, and ruthenium	184,458	347,676
Osmiridium	84,363	5,737
Quicksilver	271,984	282,752
Tin	32,943,059	38,854,579
Tungsten	139,687	1,044,986
Type metal	45,373	107,607
Uranium salts and oxide, including some radium salts	63,055	17,288
Zinc, in ore, pigs, sheets, dust, manufactures	425,205	1,585,494
Total metallic products	95,880,986	114,072,526
Increase	.....	18,191,540
Percentage of increase	.....	18.97
EXPORTS.		
Aluminum and manufactures	1,546,510	3,682,117
Bauxite concentrates	[a] 240,084	717,186
Brass, old, fit only for remanufacture	2,100,870	1,259,637
Copper, in ore, matte, ingots, bars, etc., exclusive of all other	117,633,145	117,703,941
Ferrovanadium	649,948	741,085
Iron:		
Ore	1,794,193	2,181,629
Pig	1,638,102	3,667,167
Scrap	386,208	1,111,254
Lead, in ore, pigs, sheets, dust, manufactures	5,519,908	10,067,895
Nickel	9,455,528	10,128,514
Quicksilver	70,753	225,509
Tin	1,458,383	2,496,291
Zinc, in ore, pigs, sheets, dust, manufactures	9,381,050	32,253,001
Total metallic products	151,865,682	186,235,226
Increase	.....	34,369,544
Percentage of increase	.....	22.63

[a] Figures cover period beginning July 1.

[1] Compiled by Jas. A. Dorsey from records of the Bureau of Foreign and Domestic Commerce, of the Department of Commerce.

Value of imports for consumption and of exports of mineral products in the calendar years 1914 and 1915—Continued.

Nonmetallic Products.

Product.	1914	1915
IMPORTS.		
Alizarin	$1,216,907	$854,818
Aniline salts	180,605	64,806
Arsenic sulphides, etc	273,713	267,776
Asbestos	1,779,223	2,121,003
Asphalt	675,618	680,357
Barytes	46,782	4,877
Barium products:		
Manufactured barytes	30,483	10,736
Lithopone	277,822	144,567
Barium carbonate:		
Natural	8,084	12,165
Manufactured	28,221	2,786
Barium binoxide	332,709	218,776
Barium chloride	68,866	31,295
Blanc fixe or artificial sulphate	32,619	18,501
Borax	19,412	21,281
Burrstones and millstones	15,000	17,027
Cement, hydraulic	194,053	57,174
Clay, other than kaolin	359,993	165,369
Clay products:		
Brick and tile	207,644	159,415
Flattening stones	38	12,386
Pottery, etc	8,349,442	6,612,931
Pipes, common tobacco pipes and pipe bowls of clay	40,548	15,155
Coal:		
Anthracite	25,380	4,224
Bituminous	3,902,881	4,410,772
Coal tar products (exclusive of alizarin, aniline salts, and salicylic acid)	8,303,971	4,088,217
Coke	551,104	222,382
Corundum and emery	383,436	271,649
Cryolite	94,424	82,750
Diatomaceous earth, rotten stone, and tripoli	20,004	27,333
Fertilizers:		
Crude (guano, kainite, manure salts, phosphates, etc.)	9,921,439	3,970,039
Potassium chloride	5,745,385	2,296,606
Potassium sulphate	1,557,224	664,484
Other potassium salts	1,441,364	804,134
Sodium nitrate	15,204,539	22,844,746
Flint, flints, and flint stones	432,694	274,904
Fluorspar	38,943	22,878
Fuller's earth	195,083	152,493
Gems and precious stones	19,211,084	26,193,862
Granite	158,057	144,382
Graphite	1,398,209	2,241,163
Grindstones	109,539	68,892
Gypsum	444,841	389,759
Hones, oilstones, and whetstones	33,655	14,247
Ichthyol	56,415	28,560
Kaolin, or china clay	1,927,425	1,152,778
Lead paints, litharge, orange mineral, red lead, white lead	61,330	40,223
Lime	33,670	22,489
Magnesite and magnesia	1,453,508	516,469
Marble and stone (exclusive of granite)	1,231,416	748,286
Mica (unmanufactured, ground and cut)	629,484	692,269
Mineral water	857,707	551,648
Monazite, and thorium oxide	63,282	161,805
Ocher	141,704	137,823
Peat	57,542	48,142
Petroleum and petroleum products:		
Petroleum (includes all other)	10,344,832	10,440,204
Benzine	1,120,047	4,006
Gasoline and naphtha	587	34,750
Ozokerite and paraffin wax	824,234	553,397
Paraffin oil	36,687	85,121
Pumice	92,668	65,691
Pyrite	4,797,326	4,817,977
Salicylic acid	9,245	18,373
Salt	380,803	366,452
Sand	139,675	96,754
Sienna	63,958	65,283
Slate	4,855	2,768
Strontium salts	1,016	6,411
Sulphur	477,937	472,458
Talc	177,321	199,840
Thorium nitrate	239,376	170,268

Value of imports for consumption and of exports of mineral products in the calendar years 1914 and 1915—Continued.

Nonmetallic products—Continued.

Product.	1914	1915
IMPORTS—continued.		
Umber	$45,280	$32,180
Venetian red	29,300	16,507
Zinc oxide	302,838	154,149
Total nonmetallic products	108,912,806	102,386,198
Decrease		6,526,608
Percentage of decrease		5.99
Grand total, imports	204,793,792	216,458,724
Increase		11,664,932
Percentage of increase		5.70
EXPORTS.		
Asphalt	1,247,020	1,174,637
Cement, hydraulic	3,088,809	3,361,451
Clay products:		
Brick and tile	3,051,103	1,531,210
Pottery, etc	526,902	1,174,030
Coal:		
Anthracite	20,211,072	18,429,255
Bituminous	[a]34,104,903	[a]42,817,341
Coke	2,233,686	3,092,499
Fertilizers, phosphates, crude	6,771,652	1,605,638
Graphite	493,264	589,155
Lime	170,744	106,312
Marble and stone (exclusive of granite)	1,363,242	1,036,124
Petroleum and petroleum products:		
Petroleum	120,002,974	129,777,510
Gasoline	19,897,613	13,164,159
Jelly, etc	639,848	1,034,254
Paraffin and paraffin wax	6,434,831	12,535,430
Salt	586,055	613,850
Slate	139,125	46,137
Sulphur	1,807,324	724,679
Zinc oxide	1,408,525	2,068,428
Total	224,178,692	234,882,099
Increase		10,703,407
Percentage of increase		4.77
Grand total exports	376,044,374	421,117,325
Increase		45,072,951
Percentage of increase		11.99

[a] Not including bunker coal laden as fuel in vessels in the foreign trade which aggregated in value $24,145,735 in 1914 and $25,192,956 in 1915.

If gold and silver are included, for the sake of rounding out the metals mentioned in this report, the metallic imports increased from $179,227,914 in 1914 to $600,511,070 in 1915, and the metallic exports decreased from $426,084,898 in 1914 to $271,260,028 in 1915; the total imports increased from $288,140,720 in 1914 to $702,897,268 in 1915, and the total exports decreased from $650,263,590 in 1914 to $506,142,127 in 1915. The movements of gold and silver, however, are rather financial than commercial; nevertheless the following table is added to show the results mentioned above:

Value of imports for consumption and of exports of mineral products in the calendar years 1914 and 1915, including gold and silver.

Product.	1914	1915
IMPORTS.		
Gold (ore, bullion and coin)	$57,387,741	$451,954,590
Silver (ore, bullion and coin)	25,959,187	34,483,954
Other metallic products	95,880,986	114,072,526
	179,227,914	600,511,070
Total metallic products	179,227,914	600,511,070
Total nonmetallic products	108,912,806	102,386,198
Grand total	288,140,720	702,897,268
EXPORTS.		
Gold (ore, bullion and coin)	222,616,156	31,425,918
Silver (ore, bullion and coin)	51,603,060	53,598,884
Other metallic products	151,865,682	186,235,226
	426,084,898	271,260,028
Total metallic products	426,084,898	271,260,028
Total nonmetallic products	224,178,692	234,882,099
Grand total	650,263,590	506,142,127

PRODUCTION BY STATES.

In the following tables are shown (1) the value of the mineral production of the United States in 1914 and 1915 arranged by States in order of productive value in 1915, with leading products of each State; (2) the quantity and value of the principal metals, fuels, and structural materials in 1914 and 1915, with States leading in 1915 in the production of each mineral; and (3) production by States, alphabetically, giving distribution of the mineral products credited to each State by subjects, and total value of the State output. For detailed accounts of the various products the reader should consult the complete reports by subjects.

In the report for 1913 a brief review of the mineral industry was given for each State and it is planned to bring that review up to date from time to time in this series by sketching the changes made and outlining developments in a general way. The statistical data for the years in review are given herewith complete.

Rank of States in value of mineral production in 1914 and 1915.

State.	Principal mineral products in 1915 (in order of value).[a]	1914		1915				
		Rank.	Value.	Rank.	Value.	Increase or decrease.	Percentage of increase or decrease.	Percentage of total for United States.
Pennsylvania	Coal, clay products, natural gas, cement	1	$452,824,034	1	$460,080,053	+$7,256,019	+ 1.6	22.0
West Virginia	Coal, natural gas, petroleum, clay products	2	133,633,229	2	135,111,280	+ 1,478,051	+ 1.1	6.5
Illinois	Coal, petroleum, clay products, cement	3	117,166,370	3	114,704,587	− 2,461,783	− 2.1	5.5
Ohio	Clay products, coal, natural gas, petroleum	4	101,661,384	4	105,030,948	+ 3,369,564	+ 3.3	5.0
California	Petroleum, gold, copper, cement	5	101,013,199	5	97,172,541	− 3,840,658	− 3.8	4.6
Michigan	Copper, iron, ore, cement, salt	8	57,743,555	6	93,938,255	+36,194,700	+62.7	4.5
Arizona	Copper, gold, silver, zinc	7	60,420,362	7	91,541,403	+31,121,041	+51.5	4.4
Montana	Copper, zinc, silver, gold	9	54,244,889	8	89,147,138	+34,902,249	+64.3	4.3
Oklahoma	Petroleum, natural gas, coal, zinc	6	78,744,447	9	81,311,962	+ 2,567,515	+ 3.3	3.9
Missouri	Zinc, lead, coal, clay products	11	48,597,593	10	74,489,644	+25,892,051	+53.3	3.6
Colorado	Gold, coal, zinc, silver	10	52,161,660	11	64,295,119	+12,133,459	+23.3	3.1
Utah	Copper, lead, silver, coal	13	45,636,198	12	62,586,261	+16,950,063	+37.1	3.0
Minnesota	Iron ore, clay products, stone, sand and gravel	12	45,680,865	13	62,391,440	+16,710,575	+36.6	3.0
Indiana	Coal, cement, clay products, stone	14	42,864,267	14	41,381,456	− 1,482,811	− 3.5	2.0
New Jersey	Zinc, clay products, stone, cement	16	31,756,503	15	38,818,422	+ 7,061,919	+22.2	1.8
New York	Clay products, stone, cement, salt	15	36,420,134	16	36,385,636	− 34,498	− .1	1.7
Nevada	Copper, gold, silver, zinc	19	29,984,338	17	35,479,655	+ 5,495,317	+18.3	1.7
Idaho	Lead, zinc, silver, copper	23	24,913,223	18	33,612,194	+ 8,698,971	+34.9	1.6
Alaska	Gold, copper, silver, stone	26	19,177,051	19	32,853,971	+13,676,920	+71.3	1.6
Alabama	Coal, iron ore, clay products, cement	17	30,879,288	20	29,457,407	− 1,421,881	− 4.6	1.4
Kansas	Coal, natural gas, zinc, cement	22	25,866,351	21	29,346,679	+ 3,480,328	+13.5	1.4
Texas	Petroleum, coal, natural gas, cement	18	30,363,426	22	29,269,263	− 1,094,163	− 3.6	1.4
Kentucky	Coal, clay products, stone, natural gas	20	26,668,474	23	27,276,416	+ 607,942	+ 2.3	1.3
Iowa	Coal, clay products, cement, gypsum	21	26,287,115	24	27,048,177	+ 761,062	+ 2.9	1.3
New Mexico	Copper, coal, zinc, gold	27	18,072,919	25	25,549,161	+ 7,476,242	+41.4	1.2
Tennessee	Coal, zinc, copper, stone	25	19,647,145	26	22,166,494	+ 2,519,349	+12.8	1.1
Wisconsin	Zinc, stone, iron ore, zinc and lead pigments	31	11,140,365	27	19,778,071	+ 8,637,706	+77.5	.9
Louisiana	Petroleum, sulphur, natural gas, salt	24	21,890,025	28	18,199,693	− 3,690,332	−16.9	.9
Virginia	Coal, stone, clay products, lime	28	16,400,347	29	16,991,462	+ 591,115	+ 3.6	.8
Wyoming	Coal, petroleum, iron ore, gypsum	30	12,417,752	30	12,708,238	+ 290,486	+ 2.3	.6
Washington	Coal, cement, stone, clay products	29	13,830,739	31	11,455,715	− 2,375,024	−17.2	.5
Maryland	Coal, clay products, cement, stone	32	10,587,564	32	10,433,209	− 154,355	− 1.5	.5
South Dakota	Gold, stone, silver, sand, and gravel	35	7,861,601	33	8,093,670	+ 232,069	+ 3.0	.4
Vermont	Stone, slate, talc and soapstone, lime	33	8,665,867	34	7,586,410	− 1,079,457	−12.5	.4
Arkansas	Coal, bauxite, zinc, sand and gravel	37	5,787,199	35	6,558,693	+ 771,494	+13.3	.3
Massachusetts	Stone, clay products, lime, sand and gravel	36	6,292,833	36	6,286,860	− 5,973	− .1	.3

[a] In this table iron ore, not pig iron, is taken as the basis of iron valuation, and in the case of other metals mine production (recoverable content of metals) is the basis.

Rank of States in value of mineral production in 1914 and 1915—Continued.

State.	Principal mineral products in 1915 (in order of value).[a]	1914		1915				
		Rank.	Value.	Rank.	Value.	Increase or decrease.	Percentage of increase or decrease.	Percentage of total for United States.
Georgia	Clay products, stone, cement, coal	38	5,704,856	37	5,094,688	— 610,168	−10.7	0.2
Florida	Phosphate rock, fuller's earth, stone, clay products	34	8,497,688	38	4,886,010	— 3,611,678	−42.5	.2
Oregon	Gold, stone, clay products, sand and gravel	41	3,331,132	39	3,656,545	+ 325,413	+ 9.8	.2
North Carolina	Stone, clay products, mica, gold	40	3,519,245	40	3,432,529	— 86,716	— 2.5	.2
Connecticut	Clay products, stone, lime, mineral waters	42	3,023,192	41	3,332,330	+ 309,138	+10.2	.2
Maine	Stone, lime, clay products, mineral waters	39	3,975,890	42	3,301,907	— 673,983	−17.0	.1
New Hampshire	Stone, clay products, sand and gravel, mica	43	2,029,835	43	1,903,799	— 126,036	— 6.2	.1
Nebraska	Clay products, stone, sand and gravel, cement	45	1,166,787	44	1,514,171	+ 347,384	+29.8	
South Carolina	Clay products, stone, phosphate rock, mineral waters	44	1,414,294	45	1,129,709	— 284,585	−20.1	
North Dakota	Coal, clay products, sand and gravel, mineral waters	47	1,063,540	46	985,885	— 77,655	— 7.3	
Rhode Island	Stone, clay products, mineral waters, lime	48	777,716	47	855,007	+ 77,291	+ 9.9	.3
Mississippi	Clay products, sand and gravel, mineral waters	46	1,104,197	48	666,143	— 438,054	−39.7	
Delaware	Clay products, stone, mineral waters	49	288,516	49	282,292	— 6,224	— 2.2	
District of Columbia	Clay products, sand-lime brick, sand and gravel	50	219,680	50	205,592	— 14,088	— 6.4	

[a] In this table iron ore, not pig iron, is taken as the basis of iron valuation, and in the case of other metals mine production (recoverable content of metals) is the basis.

Principal metals, fuels, and structural materials produced in the United States, 1914 and 1915.

Mineral.	Principal producing States in 1915 (in order of value).[a]	1914			1915			Increase or decrease in value.			
								By minerals.		By groups.	
		Quantity.	Value.	Value by groups.	Quantity.	Value.	Value by groups.	Amount.	Percentage.	Amount.	Percentage.
Metals (from domestic ores):											
Pig iron.....long tons..	Pennsylvania, Ohio, Illinois, New York.	21,459,852	$287,312,794		29,439,464	$388,397,654		+$101,084,860	+ 35		
Copper.....pounds..	Arizona, Montana, Michigan, Utah.	1,150,137,192	152,968,000		1,388,009,527	242,902,000		+ 89,934,000	+ 59		
Zinc.....short tons..	Missouri, Montana, New Jersey, Colorado.	343,418	35,029,000		458,135	113,617,000		+ 78,588,000	+224		
Gold.....troy ounces..	California, Colorado, Alaska, Nevada.	4,572,976	94,531,800	$649,907,294	4,887,602	101,035,700	$931,009,654	+ 6,503,900	+ 7	+$281,102,360	+43
Lead.....short tons..	Missouri, Idaho, Utah, Colorado.	512,794	39,998,000		507,026	47,660,000		+ 7,662,000	+ 19		
Silver.....troy ounces..	Nevada, Montana, Utah, Idaho.	72,455,100	40,067,700		74,961,075	37,397,300		— 2,670,400	— 7		
Fuels:											
Coal.....short tons..	Pennsylvania, West Virginia, Illinois, Ohio.	513,525,477	681,490,643		531,619,487	686,691,186		+ 5,200,543	+ 1		
Petroleum.....barrels..	Oklahoma, California, Illinois, West Virginia.	265,762,535	214,125,215	989,731,382	281,104,104	179,462,890	967,466,457	— 34,662,325	— 16	— 22,264,925	— 2
Natural gas.....	West Virginia, Pennsylvania, Ohio, Oklahoma.	.....	94,115,524		.....	101,312,381		+ 7,196,857	+ 8		
Structural materials:											
Clay products (brick and tile).	Ohio, Pennsylvania, Illinois, New Jersey.	.....	129,588,822		.....	125,794,844		— 3,793,978	— 3		
Cement.....barrels..	Pennsylvania, Indiana, California, Illinois.	87,257,552	80,533,203		87,685,222	75,155,102		— 5,378,101	— 7		
Stone.....	Pennsylvania, Ohio, New York, Vermont.	.....	77,544,103		.....	74,595,352		— 2,948,751	— 4		
Sand and gravel short tons..	Pennsylvania, Ohio, New York, Illinois.	79,281,735	23,846,999	337,384,841	76,603,303	23,121,617	324,559,479	— 725,382	— 3	— 12,825,362	— 4
Lime.....do....	Pennsylvania, Ohio, Maine, West Virginia.	3,380,928	13,268,938		3,589,699	14,336,756		+ 1,067,818	+ 8		
Gypsum.....do....	Iowa, New York, Ohio, Michigan.	2,476,465	6,895,989		2,447,611	6,596,893		— 299,096	— 4		
Slate.....	Pennsylvania, Vermont, Maine, Virginia.	.....	5,706,787		.....	4,958,915		— 747,872	— 13		

[a] Rank of States in metal production (except pig iron) arranged according to mines reports, not smelter output.

Mineral production of the United States in 1914 and 1915, by States.

Alabama.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Barytes.....short tons	(a)	(a)			(a)	(a)		
Bauxite.....long tons	(a)	(a)			(a)	(a)		
Cement.....barrels			777,698	$746,555			1,114,386	$891,483
Clay products.....short tons	27,973	b $34,607		1,574,023	31,870	b $35,232		1,193,022
Coal.....do	15,593,422	20,849,919			14,927,937	19,066,043		
Coke.....do			3,084,149	b 8,408,443			3,071,811	b 8,545,555
Ferroalloys.....long tons			(a b)	(a b)			(a b)	(a b)
Gold.....fine ounces (troy)			579	11,970			254	5,243
Graphite, crystalline.....pounds	2,410,200	118,000			3,474,800	204,572		
Iron ore.....long tons	4,514,926	5,727,619			5,134,955	6,798,266		
Iron, pig.....do			1,661,490	b17,481,828			2,320,255	b23,757,124
Lime.....short tons			46,966	199,814			60,332	250,227
Manganese ore.....long tons					200	(a)		
Mica				(a)				5,940
Millstones				(a)				
Mineral paints, natural pigments.....short tons			(a)	(a)			(a)	(a)
Mineral waters.....gallons sold	169,279	17,125			86,499	8,912		
Natural gas		(a)				(a)		
Sand and gravel.....short tons	831,430	262,219			924,701	242,336		
Silver.....fine ounces (troy)			199	110			12	6
Stone		(c)		c1,319,753		(c)		c719,452
Miscellaneous		42,382		336,325		68,561		571,592
Total value, eliminating duplications	$30,879,288				$29,457,407			

Alaska.

Antimony ore.....short tons					883	$71,638		
Barytes.....do					(a)	(a)		
Coal.....do					1,400	3,300		
Copper.....pounds			21,450,628	$2,852,934			86,509,312	$15,139,129
Gems and precious stones				300				(a)
Gold.....fine ounces (troy)			762,596	15,764,259			807,906	16,702,144

Gypsum ..... short tons	(d)			(d)	(d)			(d)
Lead ..... do			28	1,344			437	41,078
Petroleum ..... barrels	(a)	(a)			(a)	(a)		
Silver ..... fine ounces (troy)			394,805	218,327			1,071,782	543,393
Stone		(c)		(a)		(c)		(a)
Tin (metallic equivalent) ..... short tons			104	66,560			102	78,846
Tungsten ore (60 per cent concentrates) ..... do							(a)	(a)
Miscellaneous		(c)		c273,327		13,941		260,502
Total value, eliminating duplications		$19,177,051				$32,853,971		

Arizona.

Asbestos ..... short tons	(a)	(a)			(a)	(a)		
Cement ..... barrels			(a)	(a)				
Clay products				$156,167				$97,208
Copper ..... pounds			393,017,400	52,271,314			459,972,295	80,495,152
Gems and precious stones				6,812				4,998
Gold ..... fine ounces (troy)			202,167	4,179,155			201,531	4,166,025
Gypsum ..... short tons	(a)			(a)	(a)			(a)
Lead ..... do			7,502	585,120			10,809	1,021,732
Lime ..... do			19,093	122,324			14,137	90,931
Manganese ore ..... long tons					380	(a)		
Manganiferous ore ..... do					1,626	(a)		
Mineral paints, natural pigments ..... short tons			(a)	(a)			(a)	(a)
Molybdenum ..... pounds							105,157	88,116
Quicksilver ..... flasks			(a)	(a)			(a)	(a)
Sand and gravel ..... short tons	(a)	(a)			(a)	(a)		
Silica (quartz) ..... do	(a)	(a)			(a)	(a)		
Silver ..... fine ounces (troy)			4,377,994	2,421,031			5,649,020	2,864,05
Stone		(c)		c 79,341		(c)		c 90,512
Sulphuric acid (60° Baumé) e ..... short tons			(a)	(a)				
Tungsten ore (60 per cent concentrates) ..... do			15	6,435			127	245,360
Zinc ..... do			4,896	499,409			9,110	2,259,387
Miscellaneous		$10,959		82,295		$81,176		36,753
Total value, eliminating duplications		$60,420,362				$91,541,403		

a Value included under "Miscellaneous."
b Value not included in total value.
c Raw product included under derived product.
d Calcined in Washington State. Value included under "Miscellaneous."
e From copper smelting.

Mineral production of the United States in 1914 and 1915, by States—Continued.

Arkansas.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Bauxite, long tons	195,247	$976,686			208,796	$1,370,489		
Clay products, short tons	(a b)	(a b)		$451,986	(a b)	(a b)		$343,967
Coal, do	1,836,540	3,158,168			1,652,106	2,950,456		
Fuller's earth, do	(a)	(a)			(a)	(a)		
Gems and precious stones				640				1,059
Iron ore for magnets, long tons	(a)	(a)			10	(a)		
Lead, short tons			41	3,198			63	5,922
Lime, do			19,230	92,067			15,879	78,112
Manganese ore, long tons					1,343	13,333		
Manganiferous ore, do	1,970	3,940			2,000	8,544		
Mineral waters, gallons sold	1,314,159	115,205			1,377,093	119,072		
Natural gas		(a)				(a)		
Oilstones				65,215				(a)
Phosphate rock, long tons					(a)	(a)		
Sand and gravel, short tons	789,371	325,360			931,316	352,957		
Stone		(c)		c 360,735		(c)		c 255,681
Zinc, short tons			608	62,016			3,209	795,832
Miscellaneous		175,183				(c)		c 275,373
Total value, eliminating duplications	$5,787,199				$6,558,693			

California.

Antimony ore, short tons					2,208	$187,680		
Asbestos, do	(a)	(a)			(a)	(a)		
Asphalt, do	28,186	$77,810	259,972	$2,057,725	17,794	61,485	238,917	$1,516,979
Barytes, do	(a)	(a)			(a)	(a)		
Borax, do	62,400	1,464,400			67,003	1,677,099		
Briquets, fuel, do			(ab)	(ab)			(ab)	(ab)
Cement, barrels			5,004,633	6,698,905			4,532,452	6,338,918
Chromite, long tons	(a)	(a)			3,281	36,744		

Clay products	short tons	108,543	[b]139,727		4,461,661	94,598	[b]118,130		3,599,375
Coal	do	(a)	(a)			(a)	(a)		
Copper	pounds			30,507,692	4,057,523			40,751,625	7,131,534
Diatomaceous earth					89,599				(a)
Feldspar	short tons	2,778	10,715			2,004	9,550		
Ferroalloys	long tons							(ab)	(ab)
Fuller's earth	short tons	922	6,057			(a)	(a)		
Gems and precious stones					20,616				22,312
Gold	fine ounces (troy)			999,113	20,653,496			1,085,646	22,442,296
Gypsum	short tons	27,376			184,886	32,559			113,863
Iron ore	long tons	1,282	5,128			646	2,584		
Iron, pig	do			(ab)	(ab)				
Lead	short tons			2,126	165,825			2,290	215,225
Lime	do			55,492	430,792			57,292	431,424
Lithium minerals	do					(a)	(a)		
Magnesite (crude)	do	11,293	124,223			30,499	274,491		
Manganese ore	long tons	501	(a)			2,563	29,004		
Mineral paints, natural pigments	short tons			383	3,713			402	4,403
Mineral waters	gallons sold	2,282,569	497,923			2,789,871	532,817		
Natural gas			2,910,784				4,069,004		
Petroleum	barrels	99,775,327	48,066,096			86,591,535	36,558,439		
Platinum and allied metals	fine ounces (troy)			450	20,250			457	25,135
Pumice	short tons	(a)	(a)			(a)	(a)		
Pyrite	long tons	71,272	235,129			132,270	496,111		
Quicksilver	flasks			11,303	554,414			14,283	1,174,881
Salt	barrels	(c)	(c)	[c]1,100,443	[c]782,926	8,107	4,512	1,040,350	689,558
Sand and gravel	short tons	3,900,540	777,334			3,827,706	977,116		
Sand-lime brick					15,387				12,158
Silica (quartz)	short tons	2,435	7,803			3,620	19,602		
Silver	fine ounces (troy)			1,471,859	813,938			1,678,756	851,129
Stone			(c)		[c]4,610,781		(c)		[c]3,516,079
Sulphuric acid (60° Baumé) [d]	short tons			(a)	(a)			(a)	(a)
Talc	do	(c)	(c)	[c]547	[c]8,786	(c)	(c)	[c]712	[c]7,185
Tungsten ore (60 per cent concentrates)	do			(a)	(a)			962	1,005,467
Zinc	do			195	19,863			6,547	1,623,660
Miscellaneous			51,446		1,345,761		34,276		1,684,907
Total value, eliminating duplications			$101,013,199				$97,172,541		

[a] Value included under "Miscellaneous."
[b] Value not included in total value.
[c] Raw product included under derived product.
[d] From copper smelting.

Mineral production of the United States in 1914 and 1915, by States—Continued.

Colorado.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Asphalt.....short tons					(a)	(a)		
Cement.....barrels			(a)	(a)			(a)	(a)
Clay products.....short tons	57,149	b $64,152		$1,143,942	71,113	b $68,180		$1,265,105
Coal.....do	8,176,559	13,601,718			8,624,980	13,599,264		
Coke.....do			666,083	b 2,203,031			670,938	b 2,242,453
Copper.....pounds			6,639,173	883,010			7,112,537	1,244,694
Ferroalloys.....long tons			(a b)	(a b)			(a b)	(a b)
Fluorspar.....short tons	1,978	12,992			(a)	(a)		
Fuller's earth.....do	(a)	(a)						
Gems and precious stones				1,982				5,987
Gold.....fine ounces (troy)			961,845	19,883,105			1,084,323	22,414,944
Gypsum.....short tons	(a)			(a)	(a)			(a)
Iron ore.....long tons	11,464	22,846			(a)	(a)		
Iron, pig.....do			(a b)	(a b)			(a b)	(a b)
Lead.....short tons			37,106	2,894,264			34,405	3,234,098
Lime.....do			5,415	36,996			4,647	23,131
Manganese ore.....long tons					150	(a)		
Manganiferous ore.....do	39,881	13,688			30,921	61,129		
Mica				(a)				
Mineral waters.....gallons sold	968,260	113,413			858,185	63,104		
Molybdenum.....pounds							(a)	(a)
Natural gas		(a)				(a)		
Petroleum.....barrels	222,773	200,894			208,475	183,485		
Sand and gravel.....short tons	41,614	14,781			(a)	(a)		
Sand-lime brick				(a)				
Silver.....fine ounces (troy)			8,796,065	4,864,224			7,027,972	3,563,182
Stone		(c)		c 1,322,009		(c)		c 1,425,270
Sulphuric acid (60° Baumé) d.....short tons			(a)	(a)			(a)	(a)
Tungsten ore (60 per cent concentrates).....do			467	182,013			963	2,311,200
Uranium and vanadium ores				879,345				692,810
Zinc.....short tons			48,387	4,935,523			52,297	12,969,779
Miscellaneous		27,313		4,706,889		54,061		5,080,341
Total value, eliminating duplications	$52,161,660				$64,295,119			

Connecticut.

Clay products	short tons	(a b)	(a b)		$1,238,959	(a b)	(a b)		$1,529,216
Diatomaceous earth					(a)				(a)
Feldspar	short tons	16,513	$83,291			13,510	$73,124		
Gems and precious stones					10				68
Iron ore	long tons	(a)	(a)			(a)	(a)		
Iron, pig	do			(a b)	(a b)			(a b)	(a b)
Lime	short tons			70,534	338,601			76,022	368,343
Mica					(a)				(a)
Mineral waters	gallons sold	2,341,082	134,478			1,774,213	101,970		
Sand and gravel	short tons	24,343	8,128			19,350	5,137		
Sand-lime brick									(a)
Silica (quartz)	short tons	(a)	(a)			(a)	(a)		
Stone			(c)		c 1,063,184		(c)		c 1,134,947
Tungsten ore (60 per cent concentrates)	short tons							(a)	(a)
Miscellaneous			155,960		143,691		110,057		145,061
Total value, eliminating duplications			$3,023,192				$3,332,330		

Delaware.

Clay products	short tons	10,371	b $71,386		$154,718	10,148	b $61,789		$145,694
Feldspar	do	(a)	(a)						
Mineral waters	gallons sold	(a)	(a)			(a)	(a)		
Sand and gravel	short tons	(a)	(a)			(a)	(a)		
Stone			(c)		c 131,086		(c)		c 131,379
Miscellaneous			2,712				5,219		
Total value, eliminating duplications			$288,516				$282,292		

District of Columbia.

Clay products					e $148,866				e $131,134
Mineral waters	gallons sold	(a)	(a)						
Sand and gravel	short tons	(a)	(a)			(a)	(a)		
Sand-lime brick					(a)				(a)
Stone							(c)		c 5,775
Miscellaneous			31,814		39,000		(c)		c 68,683
Total value, eliminating duplications			$219,680				$205,592		

a Value included under "Miscellaneous."
b Value not included in total value.
c Raw product included under derived product.
d From zinc smelting.
e Exclusive of pottery, value for which is included under "Miscellaneous."

Mineral production of the United States in 1914 and 1915, by States—Continued.

Florida.

Product.		1914				1915			
		Raw.		Derived.		Raw.		Derived.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Clay products	short tons	(a b)	(a b)		$240,094	(a b)	(a b)		$203,414
Fuller's earth	do	(a)	(a)			(a)	(a)		
Lime	do			12,376	64,531			15,306	78,240
Mineral waters	gallons sold	231,160	$24,738			118,920	$12,516		
Phosphate rock	long tons	2,138,891	7,354,744			1,358,611	3,762,239		
Sand and gravel	short tons	177,241	54,120			123,548	34,055		
Sand-lime brick					105,435				77,575
Stone			(c)		c 343,779		(c)		c 354,673
Miscellaneous			434,247				512,298		
Total value, eliminating duplications		$8,497,688				$4,886,010			

Georgia.

Asbestos	short tons	(a)	(a)			(a)	(a)		
Barytes	do	4,882	$17,747			31,027	$102,825		
Bauxite	long tons	10,718	40,543			(a)	(a)		
Cement	barrels			(a)	(a)			(a)	(a)
Clay products	short tons	146,374	b 290,814		$2,263,034	166,250	b 319,465		$1,845,019
Coal	do	166,498	239,462			134,496	231,861		
Coke	do			24,517	b 100,529			20,039	b 81,170
Fuller's earth	do	(a)	(a)			(a)	(a)		
Gold	fine ounces (troy)			787	16,270			1,733	35,821
Iron ore	long tons	66,222	119,383			101,719	186,083		
Lime	short tons			(a)	(a)			(a)	(a)
Manganese ore	long tons					3,168	33,927		
Manganiferous ore	do					676	(a)		
Mica					(a)				635
Mineral paints, natural pigments	short tons			10,511	96,625			11,269	111,801
Mineral waters	gallons sold	652,566	49,659			746,068	53,779		
Pyrite	long tons	(a)	(a)			(a)	(a)		

Sand and gravel.....short tons	260,425	80,130			572,309	191,447		
Sand-lime brick.....				(a)				(a)
Silver.....fine ounces (troy)			67	37			138	70
Stone.....		(c)		c 2,238,789		(c)		c 1,720,313
Talc.....short tons	(c)	(c)	(a)	(a)	(c)	(c)	c 498	c 12,050
Tripoli.....								(a)
Miscellaneous.....		135,658		407,539		234,159		334,898
Total value, eliminating duplications.....		$5,704,856				$5,094,688		

Idaho.

Antimony ore.....short tons					193	$29,294		
Clay products.....do				(a)	(a b)	(a b)		(a)
Coal.....do	(a)	(a)			(a)	(a)		
Copper.....pounds			6,445,187	$857,210			6,978,713	$1,221,275
Gems and precious stones.....				800				(a)
Gold.....fine ounces (troy)			55,743	1,152,315			57,069	1,179,731
Iron ore.....long tons	(a)	(a)			(a)	(a)		
Lead.....short tons			174,263	13,592,517			173,000	16,261,975
Lime.....do			(a)	(a)			3,357	19,247
Mica.....				(a)				(a)
Phosphate rock.....long tons	(a)	(a)			(a)	(a)		
Salt.....barrels			300	520			(a)	(a)
Sand and gravel.....short tons	(a)	(a)			(a)	(a)		
Sand-lime brick.....				17,466				(a)
Silver.....fine ounces (troy)			12,479,516	6,901,172			11,769,128	5,966,948
Stone.....		(c)		c 57,909		(c)		c 31,228
Tungsten ore (60 per cent concentrates).....short tons			(a)	(a)			32	47,602
Zinc.....do			21,006	2,142,634			35,077	8,699,001
Miscellaneous.....		24,077		166,603		12,089		144,304
Total value, eliminating duplications.....		$24,913,223				$33,612,194		

a Value included under "Miscellaneous."
b Value not included in total value.
c Raw product included under derived product.

Mineral production of the United States in 1914 and 1915, by States—Continued.

Illinois.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Asphalt.....short tons			41,553	$340,862			188,575	$1,041,378
Cement.....barrels			[a] 5,284,022	[a] 4,848,522			5,553,164	4,928,679
Clay products.....short tons	161,084	[b] $168,354		13,318,953	163,904	[b] $169,320		14,791,938
Coal.....do	57,589,197	64,693,529			58,829,576	64,622,471		
Coke.....do			1,425,168	[b] 5,858,700			1,686,998	[b] 7,016,635
Ferroalloys.....long tons			[(b c)]	[(b c)]			[(b c)]	[(b c)]
Fluorspar.....short tons	73,811	426,063			[(c)]	[(c)]		
Iron, pig.....long tons			1,793,714	[b] 24,382,458			2,455,894	[b] 34,207,901
Lead.....short tons			717	55,926			954	89,676
Lime.....do			87,603	383,989			88,604	352,954
Mineral paints, zinc and lead pigments.....do			[(c)]	[(c)]			[(c)]	[(c)]
Mineral waters.....gallons sold	1,760,030	81,307			1,559,489	75,290		
Natural gas		437,275				350,371		
Petroleum.....barrels	21,919,749	25,426,179			19,041,695	18,655,850		
Pyrite.....long tons	22,538	59,079			14,849	22,476		
Sand and gravel.....short tons	7,696,130	1,859,519			7,708,012	1,984,569		
Silver.....fine ounces (troy)			2,112	1,168			3,864	1,959
Stone		[(d)]		[d] 2,934,078		[(d)]		[d] 2,907,410
Sulphuric acid (60° Baumé)[e].....short tons			243,457	1,551,876				2,046,311
Tripoli				59,304				502,937
Zinc.....short tons			4,811	490,722			5,534	1,372,432
Miscellaneous				1,272,055		[(d)]		[d] 2,261,215
Total value, eliminating duplications	$117,166,370				$114,704,587			

Indiana.

Cement.....barrels			9,615,827	$8,371,089			8,632,775	$7,357,951
Clay products.....short tons	39,055	[b] $37,644		7,655,285	52,015	[b] $45,030		7,090,630
Coal.....do	16,641,132	18,290,928			17,006,152	18,637,476		
Coke.....do			2,276,652	[b] 9,055,937			2,768,099	[b] 11,604,588
Iron, pig.....long tons			[(b c)]	[(b c)]			[(b c)]	[(b c)]

Lime	short tons			99,185	358,738		99,916	374,221
Mineral paints, natural pigments	do			(c)	(c)		(c)	(c)
Mineral waters	gallons sold	382,247	138,118			542,053	189,074	
Natural gas			755,407				695,380	
Oilstones					(c)			(c)
Petroleum	barrels	1,335,456	1,548,042			875,758	813,395	
Pyrite	long tons	1,710	5,281			972	3,080	
Sand and gravel	short tons	6,810,706	1,267,038			5,998,894	1,235,071	
Sand-lime brick					76,175			31,702
Stone			(d)		d 4,136,132		(d)	d 4,204,192
Sulphuric acid (60° Baumé) e	short tons			(c)	(c)		(c)	(c)
Miscellaneous					15,317,466			20,467,054
Total value, eliminating duplications			$42,864,267				$41,381,456	

Iowa.

Cement	barrels			4,224,076	$4,008,915		4,590,336	$4,119,952
Clay products	short tons	10,750	b $4,250		6,401,745	11,579	b $5,473	6,743,615
Coal	do	7,451,022	13,364,070			7,614,143	13,577,608	
Gypsum	do	480,404			1,321,457	495,860		1,278,128
Lime	do			(c)	(c)			(c)
Mineral paints, natural pigments	do			(c)	(c)		(c)	(c)
Mineral waters	gallons sold	303,827	30,179			198,739	18,534	
Natural gas			200				250	
Sand and gravel	short tons	2,253,254	556,868			3,002,806	720,795	
Sand-lime brick					(c)			(c)
Stone			(d)		d 538,681		(d)	d 536,175
Miscellaneous					65,000			53,120
Total value, eliminating duplications			$26,287,115				$27,048,177	

a Exclusive of natural cement, value for which is included under "Miscellaneous."
b Value not included in total value.
c Value included under "Miscellaneous."
d Raw product included under derived product.
e From zinc smelting.

Mineral production of the United States in 1914 and 1915, by States—Continued.

Kansas.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Asphalt.....short tons							(a)	(a)
Cement.....barrels			[b] 3,237,906	[b] $2,643,415			3,820,735	$2,842,443
Clay products				[c] 1,905,961				[c] 2,110,877
Coal.....short tons	6,860,988	$11,238,253			6,824,474	$11,360,630		
Gems and precious stones								(a)
Gypsum.....short tons	80,774			278,343	60,919			250,014
Lead.....do			1,409	109,902			1,212	113,928
Mineral paints, zinc and lead pigments.....do			(a)	(a)			(a)	(a)
Mineral waters.....gallons sold	272,722	56,440			155,938	63,069		
Natural gas		3,340,025				4,037,011		
Petroleum.....barrels	3,103,585	2,433,074			2,823,487	1,702,891		
Pumice.....short tons	(a)	(a)			(a)	(a)		
Salt.....barrels	1,548,286	279,730	1,419,578	644,820	1,809,471	338,562	1,955,693	697,317
Sand and gravel.....short tons	1,347,394	381,065			1,285,496	378,355		
Stone		(d)		[d] 600,576		(d)		[d] 537,165
Sulphuric acid (60° Baumé)[e].....short tons			(a)	(a)			(a)	(a)
Zinc.....do			11,284	1,150,968			14,365	3,562,520
Miscellaneous		(d)		[d] 803,779		(d)		[d] 1,351,897
Total value, eliminating duplications	$25,866,351				$29,346,679			

Kentucky.

Asphalt.....short tons	(a)	(a)			(a)	(a)		
Barytes.....do	(a)	(a)			7,753	$28,427		
Cement.....barrels			(a)	(a)			(a)	(a)
Clay products.....short tons	66,229	[f] $91,837		$2,376,406	80,684	[f] 121,676		$2,441,290
Coal.....do	20,382,763	20,852,463			21,361,674	21,494,008		
Coke.....do			443,959	[f] 971,060			526,097	[f] 1,129,769
Ferroalloys.....long tons			(af)	(af)			(af)	(af)
Fluorspar.....short tons	19,077	128,986			19,219	129,873		

Iron ore	long tons	(a)	(a)					
Iron, pig	do			57,687	f 706,120		105,700	f 1,420,275
Lead	short tons			16	1,248		251	23,594
Lime	do			5,978	26,762		1,307	7,070
Mineral waters	gallons sold	437,334	56,494			459,841	63,278	
Natural gas			490,875				614,998	
Oilstones					(a)			(a)
Petroleum	barrels	502,441	498,556			437,274	418,357	
Sand and gravel	short tons	1,563,498	539,335			944,713	397,764	
Sand-lime brick					(a)			(a)
Stone			(d)		d 1,257,722		(d)	d 1,071,052
Zinc	short tons			230	23,460		764	189,472
Miscellaneous			57,300		804,005		(d)	d 715,291
Total value, eliminating duplications			$26,668,474				$27,276,416	

Louisiana.

Asphalt	short tons			(a)	(a)		(a)	(a)
Clay products	do				c $422,062	(a f)	(a f)	c $385,002
Mineral waters	gallons sold	576,138	$31,562			513,838	$30,771	
Natural gas			(a)				2,163,934	
Petroleum	barrels	14,309,435	12,886,897			18,191,539	10,804,653	
Salt	do	(a)	(a)			(a)	(a)	
Sand and gravel	short tons	1,051,930	284,297			(a)	(a)	
Stone			(d)		(a)		(d)	(a)
Sulphur	long tons	(a)	(a)			(a)	(a)	
Miscellaneous			8,192,864		72,343		4,756,859	58,569
Total value, eliminating duplications			$21,890,025				$18,199,693	

a Value included under "Miscellaneous."
b Exclusive of natural cement, value for which is included under "Miscellaneous."
c Exclusive of pottery, value for which is included under "Miscellaneous."
d Raw product included under derived product.
e From zinc smelting.
f Value not included in total value.

Mineral production of the United States in 1914 and 1915, by States—Continued.

Maine.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Clay products				[a] $914,808				[a] $488,079
Feldspar, short tons	30,063	$194,560			27,878	$191,456		
Gems and precious stones				3,865				2,856
Lime, short tons			122,218	512,842			146,400	945,108
Mica				[b]				
Mineral waters, gallons sold	1,082,631	333,234			1,115,648	338,003		
Sand and gravel, short tons	[b]	[b]			[b]	[b]		
Silica (quartz), do	[b]	[b]			[b]	[b]		
Slate				277,419				[b]
Stone		[c]		[c] 1,723,032		[c]		[c] 1,062,283
Miscellaneous		11,600		4,530		24,310		249,812
Total value, eliminating duplications		$3,975,890				$3,301,907		

Maryland.

Briquets, fuel, short tons			[b d]	[b d]			[b d]	[b d]
Cement, barrels			[b]	[b]			[b]	[b]
Chromite, long tons	[b]	[b]						
Clay products, short tons	29,755	[d] $43,498		$1,846,500	17,157	[d] $32,966		$1,576,456
Coal, do	3,133,547	5,234,796			4,180,477	5,330,845		
Coke, do			87,852	[d] 299,739			313,283	[d] 762,664
Copper, pounds			[b]	[b]				
Diatomaceous earth				[b]				[b]
Feldspar, short tons	5,909	19,434			12,485	36,861		
Ferroalloys, long tons							[b d]	[b d]
Gold, fine ounces (troy)			11	225				
Iron ore, long tons	749	1,817			1,500	2,750		
Iron, pig, do			[b d]	[b d]			[b d]	[b d]
Lime, short tons			115,845	390,298			111,023	409,588
Mica				[b]				

Mineral paints, natural pigments	short tons			(b)	(b)		(b)	(b)
Minerals waters	gallons sold	1,691,776	124,403			1,433,406	105,581	
Sand and gravel	short tons	1,571,124	523,720			1,688,427	579,555	
Silica (quartz)	do	12,057	67,634			6,207	36,857	
Silver	fine ounces (troy)			44	24			
Slate					77,391			91,277
Soapstone	short tons			(b)	(b)		(b)	(b)
Stone			(c)		c 1,110,506		(c)	c 916,525
Miscellaneous			(c)		c 3,692,234			5,693,149
Total value, eliminating duplications		$10,587,564				$10,433,209		

Massachusetts.

Clay products	short tons	1,181	d $2,742		$1,681,557	699	d $1,313	$1,583,604
Coke	do			540,631	(b d)		504,438	(b d)
Diatomaceous earth					(b)			(b)
Fuller's earth	short tons	(b)	(b)			(b)	(b)	
Gems and precious stones					400			(b)
Iron ore	long tons	(b)	(b)			3,950	(b)	
Iron, pig	do			(b d)	(b d)		(b d)	(b d)
Lime	short tons			124,199	652,067		135,580	669,629
Mineral waters	gallons sold	3,084,385	174,324			3,872,192	184,133	
Sand and gravel	short tons	645,773	287,218			747,747	387,371	
Sand-lime brick					28,713			101,250
Silica (quartz)	short tons	(b)	(b)			(b)	(b)	
Stone			(c)		c 3,438,556		(c)	c 3,326,057
Talc	short tons			(b)	(b)		(b)	(b)
Miscellaneous			23,927		1,760,712		20,320	1,703,371
Total value, eliminating duplications		$6,292,833				$6,286,860		

a Exclusive of pottery, value for which is included under "Miscellaneous."
b Value included under "Miscellaneous."
c Raw product included under derived product.
d Value not included in total value.

Mineral production of the United States in 1914 and 1915, by States—Continued.

Michigan.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Briquets, fuel.....short tons			(a b)	(a b)			(a b)	(a b)
Bromine.....pounds			(a)	(a)			(a)	(a)
Calcium chloride.....short tons			(a)	(a)			(a)	(a)
Cement.....barrels			4,218,429	$4,064,781			4,727,768	$4,454,608
Clay products.....short tons	1,463	b $4,572		2,700,066	3,142	b $5,605		2,770,057
Coal.....do	1,283,030	2,559,786			1,156,138	2,372,797		
Coke.....do			(a b)	(a b)			(a b)	(a b)
Copper.....pounds			164,344,058	21,857,759			265,283,378	46,424,591
Gems and precious stones				300				550
Grindstones				(a)				(a)
Gypsum.....short tons	393,006			705,841	389,791			686,309
Iron ore.....long tons	8,533,280	18,722,358			13,664,437	28,218,627		
Iron, pig.....do			379,619	b 5,229,948			486,106	b 6,624,559
Lime.....short tons			66,507	287,648			81,359	349,979
Manganiferous ore.....long tons	c 192,909	(c)			(c)	(c)		
Mineral paints, natural pigments.....short tons			(a)	(a)			(a)	(a)
Mineral waters.....gallons sold	931,343	70,310			913,765	72,711		
Natural gas		1,442				1,510		
Petroleum.....barrels	(a)	(a)			(a)	(a)		
Salt.....do	(d)	(d)	d 11,670,976	d 3,299,005	(d)	(d)	d 12,588,788	d 4,304,731
Sand and gravel.....short tons	3,757,979	1,143,771			3,776,726	1,036,739		
Sand-lime brick				255,784				286,948
Scythestones				(a)				(a)
Silica (quartz).....short tons	(a)	(a)			(a)	(a)		
Silver.....fine ounces (troy)			413,500	228,665			585,933	297,068
Stone		(d)		d 1,500,910		(d)		d 1,943,668
Miscellaneous		19,091		2,508,945		26,295		3,361,412
Total value, eliminating duplications	$57,743,555				$93,938,255			

Minnesota.

Cement	barrels			(a)	(a)		(a)	(a)
Clay products	short tons	(a b)	(a b)		e $1,944,886	(a b)	(a b)	e $1,645,913
Coke	do			(a b)	(a b)		127,847	b 475,952
Gems and precious stones								(a)
Iron ore	long tons	23,298,547	$40,628,771			32,545,236	$57,742,643	
Iron, pig	do			(a b)	(a b)		(a b)	(a b)
Lime	short tons			22,057	104,195		20,359	96,190
Manganiferous ore	long tons	55,192	(a)			42,973	187,971	
Mineral waters	gallons sold	5,639,232	194,041			3,493,887	136,259	
Sand and gravel	short tons	1,074,436	417,979			1,508,890	327,975	
Sand-lime brick					119,271			151,128
Stone			(d)		d 1,513,039		(d)	d 1,492,341
Miscellaneous			225,216		1,590,027		(d)	d 1,849,770
Total value, eliminating duplications			$45,680,865				$62,391,440	

Mississippi.

Clay products	short tons	(a b)	(a b)		$530,857	(a b)	(a b)	$367,619
Gems and precious stones					21			
Iron ore	long tons	(a)	(a)					
Iron, pig	do			(a b)	(a b)			
Mineral waters	gallons sold	415,904	$73,068			259,370	$45,639	
Sand and gravel	short tons	2,144,267	499,726			1,299,813	252,885	
Miscellaneous			(d)		d 3,750		1,100	
Total value, eliminating duplications			$1,104,197				$666,143	

a Value included under "Miscellaneous."
b Value not included in total value.
c Quantity and value included in iron ore.
d Raw product included under derived product.
e Exclusive of pottery, value for which is included under "Miscellaneous."

Mineral production of the United States in 1914 and 1915, by States—Continued.

Missouri.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Barytes.....short tons	33,317	$112,231			39,113	$158,597		
Briquets, fuel.....do			(a b)	(a b)			(a b)	(a b)
Cement.....barrels			4,706,389	$4,485,744			4,628,484	$4,007,679
Clay products.....short tons	209,181	b 463,703		6,077,284	308,385	b 641,040		5,431,569
Coal.....do	3,935,980	6,802,325			3,811,593	6,595,918		
Coke.....do							(a b)	(a b)
Copper.....pounds			44,463	5,914			402,160	70,378
Gems and precious stones				8				
Iron ore.....long tons	36,304	75,696			40,290	99,853		
Iron, pig.....do			(a b)	(a b)			(a b)	(a b)
Lead.....short tons			192,612	15,023,736			210,440	19,781,360
Lime.....do			155,680	686,051			135,901	573,442
Mineral paints:								
Natural pigments.....do			(a)	(a)			(a)	(a)
Zinc and lead pigments.....do			(a)	(a)			(a)	(a)
Mineral waters.....gallons sold	583,288	74,793			1,000,961	83,363		
Natural gas		5,319				7,731		
Petroleum.....barrels	(a)	(a)			(a)	(a)		
Pyrite.....long tons	(a)	(a)			(a)	(a)		
Sand and gravel.....short tons	3,528,678	1,020,903			2,889,211	675,484		
Silver.....fine ounces (troy)			61,168	33,826			57,756	29,282
Stone		(c)		c 2,294,103		(c)		c 2,145,501
Tripoli				81,434				68,451
Zinc.....short tons			105,994	10,811,388			136,300	33,802,400
Miscellaneous		16,768		1,327,506		37,256		1,900,098
Total value, eliminating duplications		$48,597,593				$74,489,644		

Montana.

Cement	barrels			(a)	(a)		(a)	(a)
Clay products	short tons	2,978	b $9,648		d $440,519	3,670	b $17,842		d $524,575
Coal	do	2,805,173	4,913,191			2,789,755	4,526,509		
Copper	pounds			233,229,640	31,019,542			267,231,014	46,765,427
Gems and precious stones					67,452				105,355
Gold	fine ounces (troy)			199,204	4,117,911			242,078	5,004,195
Graphite, crystalline	pounds	(a)	(a)			(a)	(a)		
Gypsum	short tons	(a)			(a)	(a)			(a)
Iron ore	long tons	(a)	(a)						
Lead	short tons			4,828	376,584			6,878	646,549
Lime	do			(a)	(a)			(a)	(a)
Mineral waters	gallons sold	100,700	5,555			114,245	6,603		
Natural gas							(a)		
Sand and gravel	short tons	17,864	17,075			16,387	13,205		
Silver	fine ounces (troy)			12,016,460	6,645,102			14,378,437	7,289,868
Stone			(c)		c 242,030		(c)		c 263,812
Zinc	short tons			55,790	5,690,608			93,573	23,206,215
Miscellaneous			8,581		700,739		3,925		790,900
Total value, eliminating duplications			$54,244,889				$89,147,138		

Nebraska.

Cement	barrels			(a)	(a)		(a)	(a)
Clay products	short tons	(a b)	(a b)		d $640,955	(a b)	(a b)		d $776,899
Gems and precious stones					8				
Mineral waters	gallons sold	10,900	$1,490			8,770	$962		
Pumice	short tons	(a)	(a)			(a)	(a)		
Sand and gravel	do	859,962	141,319			1,075,139	200,920		
Sand-lime brick					(a)				(a)
Stone			(c)		c 303,680		(c)		c 321,341
Miscellaneous			58,372		21,663		58,940		155,714
Total value, eliminating duplications			$1,166,787				$1,514,171		

a Value included under "Miscellaneous."
b Value not included in total value.
c Stone sold rough included under derived product.
d Exclusive of pottery, value for which is included under "Miscellaneous."

Mineral production of the United States in 1914 and 1915, by States—Continued.

Nevada.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Antimony ore.....short tons					1,500	$110,000		
Clay products				(a)				(a)
Coal.....short tons	(a)	(a)			(a)	(a)		
Copper.....pounds			60,986,450	$8,111,198			68,636,370	$12,011,365
Diatomaceous earth				(a)				(a)
Gems and precious stones				8,584				6,333
Gold.....fine ounces (troy)			555,402	11,481,188			551,683	11,404,300
Graphite, amorphous.....short tons	(a)	(a)			(a)	(a)		
Gypsum.....do	(a)			(a)	(a)			(a)
Iron ore.....long tons	(a)	(a)			3,993	(a)		
Lead.....short tons			6,405	499,577			8,319	781,952
Lime.....do			(a)	(a)			(a)	(a)
Manganiferous ore.....long tons					(a)	(a)		
Mineral waters.....gallons sold	221,942	$3,191			303,150	4,294		
Molybdenum.....pounds							(a)	(a)
Platinum and allied metals.....fine ounces (troy)			278	12,342				
Quicksilver.....flasks			2,089	102,465			2,327	209,911
Salt.....barrels	(b)	(b)	b 4,436	b 2,448			6,929	3,950
Sand and gravel.....short tons	(a)	(a)			17,491	1,775		
Silver.....fine ounces (troy)			15,455,491	8,546,887			14,459,840	7,331,139
Sulphur.....long tons	(a)	(a)			(a)	(a)		
Tungsten ore (60 per cent concentrates).....short tons							55	130,466
Zinc.....do			6,490	661,992			12,188	3,022,680
Miscellaneous		97,095		457,371		43,921		417,569
Total value, eliminating duplications	$29,984,338				$35,479,655			

New Hampshire.

Clay products				[c] $398,066				[c] $484,464
Diatomaceous earth								[a]
Feldspar, short tons	[a]	[a]			[a]	[a]		
Fluorspar, do	[a]	[a]			[a]	[a]		
Garnet, do	[a]	[a]			[a]	[a]		
Gems and precious stones				615				200
Lead, short tons							[a]	[a]
Mica				47,837				66,971
Mineral waters, gallons sold	194,418	$11,731			176,385	$6,737		
Sand and gravel, short tons	670,000	112,500			583,200	77,760		
Scythestones				[a]				[a]
Silver, fine ounces (troy)							26	13
Stone		[b]		[b] 1,383,325		[b]		[b] 1,234,149
Zinc, short tons			6	635			[a]	[a]
Miscellaneous		12,840		62,286		11,770		21,735
Total value, eliminating duplications		$2,029,835				$1,903,799		

New Jersey.

Briquets, fuel, short tons			[a d]	[a d]				
Cement, barrels			3,530,476	$3,081,205			1,977,474	$1,473,499
Clay products, short tons	373,703	[d] $648,584		16,484,652	340,726	[d] $617,904		15,965,418
Coke, do			[a d]	[a d]			[a d]	[a d]
Greensand marl, do	992	760			866	433		
Iron ore, long tons	346,820	1,076,208			391,115	1,140,400		
Iron, pig, do			[a d]	[a d]			[a d]	[a d]
Lime, short tons			10,953	41,226			10,273	35,393
Manganiferous zinc residuum [e], long tons	100,198	[a]			159,318	[a]		
Mineral waters, gallons sold	1,710,030	155,649			1,479,479	116,226		
Sand and gravel, short tons	4,665,677	1,544,322			4,968,104	1,447,557		
Sand-lime brick				[a]				[a]
Slate				[a]				6,551
Stone		[b]		[b] 1,533,668		[b]		[b] 1,601,044
Talc, short tons	[a]	[a]			[b]	[b]	[a]	[a]
Zinc, do			74,253	[a]			116,618	[a]
Miscellaneous		304,143		9,718,602		[b]		[b] 18,844,554
Total value, eliminating duplications		$31,756,503				$38,818,422		

[a] Value included under "Miscellaneous."
[b] Raw product included under derived product.
[c] Exclusive of pottery, value for which is included under "Miscellaneous."
[d] Value not included in total value.
[e] Ore mined in New Jersey; smelted in Pennsylvania.

Mineral production of the United States in 1914 and 1915, by States—Continued.

New Mexico.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Clay products.....short tons	2,042	a $4,695		$205,914	2,568	a $7,320		$240,847
Coal.....do	3,877,689	6,230,871			3,817,940	5,481,361		
Coke.....do			362,572	a 1,228,045			389,411	a 1,265,268
Copper.....pounds			59,307,925	7,887,954			76,788,366	13,437,964
Fluorspar.....short tons					(b)	(b)		
Gems and precious stones				55				(b)
Gold.....fine ounces (troy)			56,681	1,171,696			70,681	1,461,105
Gypsum.....short tons	(b)			(b)	(b)			(b)
Iron ore.....long tons	(b)	(b)			34,806	54,197		
Lead.....short tons			882	68,782			2,271	213,491
Lime.....do			(b)	(b)			1,720	11,963
Mica				(b)				
Mineral waters.....gallons sold	41,000	6,600			42,400	6,680		
Salt.....barrels			(b)	(b)			(b)	(b)
Sand and gravel.....short tons	(b)	(b)			(b)	(b)		
Silver.....fine ounces (troy)			1,777,445	982,927			2,005,531	1,016,804
Stone		(c)		c 418,305		(c)		c 308,809
Tungsten ore (60 per cent concentrates).....short tons			(b)	(b)			45	70,934
Zinc.....do			9,202	938,573			12,702	3,150,104
Miscellaneous		84,272		76,970		8,880		86,022
Total value, eliminating duplications	$18,072,919				$25,549,161			

New York.

Abrasives, artificial.....pounds			(a b)	(a b)			(a b)	(a b)
Aluminum.....do			(a b)	(a b)			(a b)	(a b)
Briquets, fuel.....short tons			(a b)	(a b)				
Cement.....barrels			5,713,383	$5,143,401			5,504,365	$4,153,802
Clay products.....short tons	5,640	a $7,286		9,078,933	7,261	a $15,913		9,489,002
Coke.....do			457,370	a 1,726,133			684,461	a 2,459,463
Diatomaceous earth				(b)				(b)
Emery.....short tons	485	2,425			3,063	31,131		
Feldspar.....do	19,579	102,027			17,375	65,988		
Garnet, abrasive.....do	4,026	139,670			3,951	136,514		
Gems and precious stones								(b)

Graphite:								
Artificial pounds			10,455,139	a 698,800			5,084,000	a 99,633
Crystalline do	(b)	(b)			(b)	(b)		
Gypsum short tons	523,368			1,237,192	540,914			1,267,706
Iron ore long tons	640,252	1,992,892			931,745	2,797,270		
Iron, pig do			1,357,575	a 19,353,309			2,010,076	a 28,178,466
Lime short tons			94,009	396,494			115,861	575,384
Mica								(b)
Millstones				16,748				16,883
Mineral paints, natural pigments short tons			16,025	150,837			13,354	112,108
Mineral waters gallons sold	8,201,202	672,913			8,411,616	711,697		
Natural gas		2,600,352				2,335,252		
Petroleum barrels	938,974	1,760,868			887,778	1,390,325		
Pyrite long tons	(b)	(b)			(b)	(b)		
Salt barrels	(c)	(c)	c 10,389,314	c 2,824,733	(c)	(c)	c 11,217,471	c 2,976,405
Sand and gravel short tons	7,070,820	2,250,169			7,449,807	2,416,522		
Sand-lime brick				107,633				121,114
Silica (quartz) short tons					(b)	(b)		
Slate				112,776				127,603
Stone		(c)		c 6,575,079		(c)		c 5,731,849
Talc, fibrous short tons			86,075	821,286			88,214	864,843
Zinc do							(b)	(b)
Miscellaneous		425,934		11,000,996		446,224		16,989,512
Total value, eliminating duplications	$36,420,134				$36,385,636			

North Carolina.

Barytes short tons	(b)	(b)			(b)	(b)		
Clay products do	17,773	a $164,837		$1,460,790	16,069	a $143,696		$1,089,935
Copper pounds			20,434	2,718			17,170	3,005
Feldspar short tons	15,420	43,153			(b)	(b)		
Gems and precious stones				3,070				464
Gold fine ounces (troy)			6,344	131,141			8,321	172,001
Iron ore long tons	(b)	(b)			66,453	(b)		
Lime short tons			8,098	36,356			5,842	28,735
Mica				195,270				300,593
Millstones				5,164				(b)
Mineral waters gallons sold	158,226	21,964			132,813	18,745		
Sand and gravel short tons	492,092	72,989			424,740	124,697		
Silica (quartz) do	(b)	(b)			(b)	(b)		
Silver fine ounces (troy)			1,524	843			1,465	743
Stone		(c)		c 1,407,671		(c)		c 1,409,963
Talc short tons	300	600	898	27,813	(c)	(c)	c 1,454	c 21,501
Miscellaneous		109,703				(c)		c 262,147
Total value, eliminating duplications	$3,519,245				$3,432,529			

a Value not included in total value. b Value included under "Miscellaneous." c Raw product included under derived product.

Mineral production of the United States in 1914 and 1915, by States—Continued.

North Dakota.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Briquets, fuel.....short tons			(a b)	(a b)			(a b)	(a b)
Clay products.....do	(a b)	(a b)		$266,046	(a b)	(a b)		$189,355
Coal.....do	506,685	$771,379			528,078	$766,072		
Mineral waters.....gallons sold	408,000	8,150			475,000	8,750		
Natural gas		(a)				(a)		
Sand and gravel.....short tons	23,210	11,325			30,240	12,135		
Sand-lime brick				(a)				(a)
Miscellaneous		3,584		15,994		2,739		14,218
Total value, eliminating duplications	$1,063,540				$985,885			

Ohio.

Bromine.....pounds			(a)	(a)			125,135	$165,648
Calcium chloride.....short tons			4,044	$22,789			5,418	30,406
Cement.....barrels			1,951,472	1,942,927			1,983,217	1,940,824
Clay products.....short tons	324,333	b $247,356		37,166,768	285,590	b $247,413		36,839,621
Coal.....do	18,843,115	21,250,642			22,434,691	24,207,075		
Coke.....do			521,638	b 1,678,686			684,658	b 2,136,933
Ferroalloys.....long tons			(a b)	(a b)			82,637	b 1,414,971
Grindstones and pulpstones				606,001				571,113
Gypsum.....short tons	265,091			773,413	259,036			772,520
Iron ore.....long tons	(a)	(a)			3,502	8,535		
Iron, pig.....do			5,226,925	b 70,331,114			6,995,000	b 90,549,626
Lime.....short tons			480,010	1,880,836			507,993	1,954,810
Mineral waters.....gallons sold	3,558,413	145,586			3,504,343	133,416		
Natural gas		14,667,790				17,391,060		
Oilstones and scythestones				11,582				(a)
Petroleum.....barrels	8,536,352	13,372,729			7,825,326	10,051,493		
Pyrite.....long tons	7,279	19,718			10,857	27,404		

Salt ..... barrels			5,482,836	1,320,554			5,880,243	1,462,192
Sand and gravel ..... short tons	5,510,879	2,157,131		(a)	6,861,023	2,634,145		(a)
Sand-lime brick				c 5,655,713				c 5,816,923
Stone		(c)		(a)		(c)		(a)
Sulphuric acid (60° Baumé)[d] ..... short tons			(a)	c 1,124,528			(a)	1,013,763
Miscellaneous		(c)						
Total value, eliminating duplications		$101,661,384				$105,030,948		

Oklahoma.

Asphalt ..... short tons	9,669	$73,535	(a)	(a)	16,907	$118,351	(a)	(a)
Cement ..... barrels			(a)	(a)			(a)	(a)
Clay products				$786,314				$996,451
Coal ..... short tons	3,988,613	8,204,015			3,693,580	7,435,906		
Gypsum ..... do	113,103			312,856	110,790			294,230
Lead ..... do			7,556	589,368			7,306	686,764
Lime ..... do			2,293	11,130			(a)	(a)
Mineral waters ..... gallons sold	804,675	26,906			890,392	24,005		
Natural gas		8,050,039				9,195,804		
Petroleum ..... barrels	73,631,724	57,253,187			97,915,243	56,706,133		
Salt ..... do			(a)	(a)			(a)	(a)
Sand and gravel ..... short tons	1,477,618	713,117			(a)	(a)		
Sand-lime brick				(a)				
Silver ..... fine ounces (troy)			6,187	3,421				
Stone		(c)		c 263,673		(c)		c 430,302
Tripoli				(a)				
Zinc ..... short tons			13,992	1,427,184			14,314	3,549,872
Miscellaneous				1,029,702		(c)		c 1,874,144
Total value, eliminating duplications		$78,744,447				$81,311,962		

a Value included under "Miscellaneous."
b Value not included in total value.
c Raw product included under derived product.
d From zinc smelting.

Mineral production of the United States in 1914 and 1915, by States—Continued.

Oregon.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Antimony ore.....short tons					(a)	(a)		
Briquets, fuel.....do			(a b)	(a b)			(a b)	(a b)
Clay products.....do	(a b)	(a b)		c $560,271	(a b)	(a b)		c $341,243
Coal.....do	51,558	$143,556			39,231	$111,240		
Copper.....pounds			39,248	5,220			451,172	78,955
Diatomaceous earth								(a)
Gems and precious stones				1,600				4,252
Gold.....fine ounces (troy)			76,987	1,591,461			90,064	1,861,796
Gypsum.....short tons	(a)			(a)	(a)			(a)
Lead.....do			8	641			31	2,959
Lime.....do			3,143	21,576			4,188	30,411
Mineral waters.....gallons sold	57,800	12,810			28,747	8,729		
Platinum and allied metals.....fine ounces (troy)			75	3,375			(a)	(a)
Quicksilver.....flasks							(a)	(a)
Sand and gravel.....short tons	1,271,362	390,177			880,633	301,425		
Silver.....fine ounces (troy)			142,552	78,831			117,947	57,799
Stone		(d)		d 435,066		(d)		d 753,285
Miscellaneous		(d)		d 231,230		5,350		240,606
Total value, eliminating duplications	$3,331,132				$3,656,545			

Pennsylvania.

Abrasives, artificial.....pounds			(a b)	(a b)			(a b)	(a b)
Briquets, fuel.....short tons			92,137	b $228,097			29,561	b $85,841
Bromine.....pounds			(a)	(a)				
Calcium chloride.....short tons			(a)	(a)				
Cement.....barrels			26,061,332	20,977,055			28,230,027	20,267,414
Clay products.....short tons	376,697	b $715,458		21,846,996	441,918	b $735,321		22,726,031
Coal:								
Anthracite.....do	90,821,507	188,181,399			88,995,061	184,653,498		
Bituminous.....do	147,983,294	159,006,296			157,955,137	167,419,705		
Coke.....do			20,258,393	b 42,447,886			25,622,862	b 52,667,018

Copper ..... pounds			(a)	(a)			(a)	(a)
Feldspar ..... short tons	10,101	71,393			15,830	120,984		
Ferroalloys ..... long tons			149,342	b 6,519,636			207,936	b 11,919,060
Gems and precious stones								(a)
Graphite, crystalline ..... pounds	(a)	(a)			(a)	(a)		
Iron ore ..... long tons	400,062	399,639			367,056	333,697		
Iron, pig ..... do			9,267,197	b 127,686,331			12,779,974	b 174,926,891
Lead ..... short tons							(a)	(a)
Lime ..... do			849,963	2,740,238			901,549	2,947,058
Millstones				(a)				(a)
Mineral paints:								
Natural pigments ..... do			30,761	297,010			21,116	191,891
Zinc and lead pigments ..... do			(a)	(a)			(a)	(a)
Mineral waters ..... gallons sold	2,457,626	213,752			2,136,218	174,798		
Natural gas		20,839,869				21,139,605		
Oilstones				(a)				(a)
Petroleum ..... barrels	8,170,335	15,573,822			7,838,705	12,431,353		
Pyrite ..... long tons					(a)	(a)		
Salt ..... barrels			(a)	(a)				
Sand and gravel ..... short tons	6,866,077	2,937,957			6,164,400	2,776,812		
Sand-lime brick				54,418				56,848
Silica (quartz) ..... short tons	(a)	(a)			(a)	(a)		
Slate				3,609,959				3,044,269
Stone		(d)		d 8,153,413		(d)		d 9,310,397
Sulphuric acid (60° Baumé) c ..... short tons			(a)	(a)			(a)	(a)
Talc ..... do			(a)	(a)	(d)	(d)	(a)	(a)
Tripoli				(a)				(a)
Miscellaneous		17,430		7,950,388		56,623		12,482,070
Total value, eliminating duplications		$452,824,034				$460,080,053		

Rhode Island.

Clay products				(a)				(a)
Graphite, amorphous ..... short tons	(a)	(a)			(a)	(a)		
Lime ..... do			(a)	(a)			(a)	(a)
Mineral waters ..... gallons sold	438,702	$29,639			385,624	$24,574		
Sand and gravel ..... short tons	(a)	(a)			(a)	(a)		
Soapstone ..... do	(a)	(a)	(a)	(a)	(a)	(a)		
Stone		(d)		d $625,276		(d)		d $693,950
Miscellaneous		6,540		116,261		10,693		125,790
Total value, eliminating duplications		$777,716				$855,007		

a Value included under "Miscellaneous."
b Value not included in total value.
c Exclusive of pottery, value for which is included under "Miscellaneous."
d Raw product included under derived product.
e From zinc smelting.

Mineral production of the United States in 1914 and 1915, by States—Continued.

South Carolina.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Barytes.....short tons	(a)	(a)			(a)	(a)		
Clay products.....do	28,421	b $133,047		$568,645	24,854	b $119,218		$379,133
Gems and precious stones				5				(a)
Gold.....fine ounces (troy)			356	7,360			183	3,789
Lime.....short tons			(a)	(a)			(a)	(a)
Manganese ore.....long tons	410	(a)						
Mica				(a)				(a)
Mineral waters.....gallons sold	293,949	48,071			480,051	67,869		
Phosphate rock.....long tons	106,919	415,039			83,460	310,850		
Pyrite.....do					(a)	(a)		
Sand and gravel.....short tons	33,788	8,480			109,011	21,440		
Silver.....fine ounces (troy)			33	18			8	4
Stone		(c)		c 357,657		(c)		c 321,612
Miscellaneous		2,130		6,889		22,289		2,723
Total value, eliminating duplications		$1,414,294				$1,129,709		

South Dakota.

Antimony ore.....short tons					(a)	(a)		
Clay products				$57,711				$36,342
Coal.....short tons	11,850	$20,456			10,593	$16,384		
Gems and precious stones				404				(a)
Gold.....fine ounces (troy)			354,758	7,333,508			358,280	7,406,305
Gypsum.....short tons	(a)			(a)	(a)			(a)
Lead.....do			2	152			2	146
Lime.....do			5,603	36,976			5,625	34,728
Lithium minerals.....do	(a)	(a)			(a)	(a)		
Mica				(a)				10,914
Mineral waters.....gallons sold	145,647	8,999			176,000	9,360		
Natural gas		(a)				(a)		

Sand and gravel	short tons	232,395	40,215		27,665	256,270	45,717	18,402
Sand-lime brick								
Silica (quartz)	short tons	(a)	(a)					
Silver	fine ounces (troy)			176,642	97,683		199,864	101,331
Stone			(c)		c 156,907		(c)	c 159,089
Tungsten ore (60 per cent concentrates)	short tons						140	181,089
Miscellaneous			32,780		48,145		32,089	41,774
Total value, eliminating duplications			$7,861,601				$8,093,670	

Tennessee.

Aluminum	pounds			(a b)	(a b)		(a b)	(a b)
Barytes	short tons	10,113	$16,273			25,074	$71,390	
Bauxite	long tons	(a)	(a)			(a)	(a)	
Cement	barrels			(a)	(a)		(a)	(a)
Clay products	short tons	62,861	b 129,976		$1,546,315	59,975	b 123,132	$1,548,220
Coal	do	5,943,258	6,776,573			5,730,361	6,479,916	
Coke	do			264,127	b 642,573		256,973	b 674,014
Copper	pounds			18,737,656	2,492,108		18,046,010	3,158,051
Ferroalloys	long tons			(a b)	(a b)		(a b)	(a b)
Gold	fine ounces (troy)			300	6,194		332	6,862
Iron ore	long tons	330,214	466,523			283,841	408,204	
Iron, pig	do			178,481	b 2,150,452		208,298	b 2,519,337
Lead	short tons						1	73
Lime	do			85,939	266,881		82,765	256,069
Manganese ore	long tons					(a)	(a)	
Mineral paints, natural pigments	short tons			(a)	(a)		(a)	(a)
Mineral waters	gallons sold	943,502	56,741			703,566	39,304	
Natural gas			300				400	
Phosphate rock	long tons	483,203	1,822,770			389,748	1,327,687	
Sand and gravel	short tons	1,097,720	400,182			1,015,055	376,826	
Silica (quartz)	do	(a)	(a)			(a)	(a)	
Silver	fine ounces (troy)			97,402	53,864		100,543	50,975
Stone			(c)		c 1,932,462		(c)	c 1,814,782
Sulphuric acid (60° Baumé) d	short tons			(a)	(a)		(a)	(a)
Zinc	do			10,425	1,063,350		16,461	4,082,440
Miscellaneous			73,702		4,936,043		52,670	5,044,800
Total value, eliminating duplications			$19,647,145				$22,166,494	

a Value included under "Miscellaneous." b Value not included in total value. c Stone sold rough included under derived product. d From copper smelting.

Mineral production of the United States in 1914 and 1915, by States—Continued.

Texas.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Asphalt.....short tons	(a)	(a)	57,934	$608,132	(a)	(a)	98,813	$1,263,757
Cement.....barrels			2,096,140	2,686,653			1,932,828	2,518,233
Clay products.....short tons	2,362	[b] $9,616		2,280,987	3,204	[b] $10,610		1,976,890
Coal.....do	2,323,773	3,922,459			2,088,908	3,445,487		
Copper.....pounds			23,760	3,160			42,491	7,436
Fuller's earth.....short tons	(a)	(a)			(a)	(a)		
Gems and precious stones				1,725				(a)
Gold.....fine ounces (troy)			11	234			73	1,503
Gypsum.....short tons	158,814			490,937	176,306			519,879
Lead.....do			75	5,812			110	10,307
Lime.....do			37,365	200,788			39,468	211,516
Manganese ore.....long tons					(a)	(a)		
Mineral waters.....gallons sold	766,597	93,014			835,142	100,090		
Natural gas		2,469,770				2,593,873		
Petroleum.....barrels	20,068,184	14,942,848			24,942,701	13,026,925		
Quicksilver.....flasks			(a)	(a)			(a)	(a)
Salt.....barrels			334,979	251,493			444,978	345,944
Sand and gravel.....short tons	1,681,379	638,026			1,912,303	533,808		
Sand-lime brick				(a)				52,941
Silver.....fine ounces (troy)			530,817	293,542			675,473	342,465
Stone		(c)		[c] 870,224		(c)		[c] 726,323
Sulphur.....long tons	(a)	(a)			(a)	(a)		
Zinc.....short tons			108	11,039			15	3,769
Miscellaneous		384,972		207,611		(c)		[c] 1,588,117
Total value, eliminating duplications		$30,363,426				$29,269,263		

Utah.

Antimony ore.....short tons					(a)	(a)		
Asphalt.....do	23,098	$424,480			21,709	$281,002		
Cement.....barrels			974,723	$1,317,575			655,116	$823,995
Clay products.....short tons	5,837	[b] 13,961		[d] 676,142	5,398	[b] 8,807		[d] 699,962

Coal	do	3,103,036	4,935,454			3,108,715	4,916,916	
Coke	do			(a b)	(a b)			(a b)
Copper	pounds			152,034,002	20,220,522			187,671,188
Gems and precious stones					5,023			
Gold	fine ounces (troy)			157,961	3,265,347			174,591
Gypsum	short tons	44,950			184,621	23,445		
Iron ore	long tons	(a)	(a)			(a)	(a)	
Lead	short tons			85,662	6,681,602			99,984
Lime	do			12,425	74,212			11,460
Manganese ore	long tons					(a)	(a)	
Mineral waters	gallons sold	(a)	(a)			(a)	(a)	
Phosphate rock	long tons					(a)	(a)	
Salt	barrels	42,414	16,662	333,043	214,850	31,478	10,109	363,372
Sand and gravel	short tons	235,856	59,628			261,611	32,197	
Silver	fine ounces (troy)			11,154,916	6,168,669			12,313,205
Slate					(a)			
Stone			(c)		c498,810		(c)	
Tungsten ore (60 per cent concentrates)	short tons			(a)	(a)			(a)
Uranium and vanadium ores					61,955			
Zinc	short tons			7,995	815,453			12,146
Miscellaneous			10,672		1,459,065		12,375	
Total value, eliminating duplications			$45,636,198				$62,586,261	

Vermont.								
Clay products	short tons	4,976	b $33,701		$75,847	5,388	b $37,081	
Copper	pounds							(a)
Lime	short tons			28,758	142,034			37,992
Mineral paints, natural pigments	do			(a)	(a)			(a)
Mineral waters	gallons sold	51,151	8,600			61,540	14,382	
Sand and gravel	short tons	108,359	11,538			76,590	23,942	
Scythestones					(a)			
Silver	fine ounces (troy)							353
Slate					1,414,247			
Stone			(c)		c 6,635,477		(c)	
Talc and soapstone	short tons			50,698	363,465			62,497
Miscellaneous					14,659			
Total value, eliminating duplications			$8,665,867				$7,586,410	

$71,642			
(a)			
187,144			
(a)			
(a)			
179			
1,234,891			
c 5,620,899			
409,652			
23,679			

a Value included under "Miscellaneous."
b Value not included in total value.
c Raw product included under derived product.
d Exclusive of pottery, value for which is included under "Miscellaneous."

Mineral production of the United States in 1914 and 1915, by States—Continued.

Virginia.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Asbestos.....short tons	(a)	(a)						
Barytes.....do	(a)	(a)			(a)	(a)		
Briquets, fuel.....do			(a b)	(a b)			(a b)	(a b)
Cement.....barrels			(a)	(a)			(a)	(a)
Clay products.....short tons	2,177	b $2,722		c $1,472,348	4,958	b $4,333		c $1,447,802
Coal.....do	7,959,535	8,032,448			8,122,596	7,962,934		
Coke.....do			780,984	b 1,582,419			629,807	b 1,242,938
Copper.....pounds			139,008	18,488			27,744	4,855
Diatomaceous earth								(a)
Feldspar.....short tons	(a)	(a)			(a)	(a)		
Gems and precious stones								(a)
Gold.....fine ounces (troy)			21	429			26	534
Gypsum.....short tons	(a)			(a)	(a)			(a)
Iron ore.....long tons	346,382	719,415			334,424	696,920		
Iron, pig.....do			197,981	b 2,481,197			265,616	b 3,408,784
Lead.....short tons			127	9,906			339	31,901
Lime.....do			243,990	763,775			267,278	840,969
Manganese ore.....long tons	1,724	18,565			1,620	17,988		
Manganiferous ore.....do	1,222	4,524			1,944	6,708		
Mica				24,653				10,418
Millstones				20,100				23,170
Mineral paints, natural pigments.....short tons			(a)	(a)			(a)	(a)
Mineral waters.....gallons sold	2,906,976	293,512			3,027,528	237,818		
Pyrite.....long tons	141,276	556,091			145,050	729,644		
Salt.....barrels			(a)	(a)			(a)	(a)
Sand and gravel.....short tons	639,382	229,595			870,219	234,112		
Silver.....fine ounces (troy)			1,458	806				
Slate				204,139				210,612
Stone		(d)		d 2,152,378		(d)		d 2,586,427
Talc and soapstone.....short tons	571	1,852	21,116	526,086	(d)	(d)	d 22,741	d 504,742
Titanium minerals:								
Ilmenite.....do			89	4,895			(e)	(e)
Rutile.....do			94	11,280			250	27,500
Zinc.....do			174	17,748			1,267	314,113
Miscellaneous		102,735		1,234,579		10,635		1,096,160
Total value, eliminating duplications		$16,400,347				$16,991,462		

Washington.

Antimony ore	short tons					(a)	(a)		
Briquets, fuel	do			(a b)	(a b)			(a b)	(a b)
Cement	barrels			2,045,465	$2,303,433			1,378,107	$1,790,499
Clay products	short tons	691	b $3,829		c 1,809,491	829	b $4,340		c 1,454,436
Coal	do	3,064,820	6,751,511			2,429,095	5,276,299		
Coke	do			84,923	b 472,531			136,552	b 700,832
Copper	pounds			778,728	103,571			1,020,926	178,662
Diatomaceous earth					(a)				(a)
Gold	fine ounces (troy)			26,953	557,173			18,935	391,419
Lead	short tons			33	2,555			148	13,875
Lime	do			29,430	189,260			27,240	171,023
Mineral paints, natural pigments	do			(a)	(a)			(a)	(a)
Mineral waters	gallons sold	180,787	28,777			158,865	11,703		
Sand and gravel	short tons	1,178,330	324,628			772,629	211,480		
Sand-lime brick					(a)				(a)
Silver	fine ounces (troy)			264,861	146,468			255,837	129,709
Stone			(d)		d 1,600,615		(d)		d 1,758,817
Tungsten ore (60 per cent concentrates)	short tons							(a)	(a)
Zinc	do							122	30,368
Miscellaneous					78,926		(d)		d 243,585
Total value, eliminating duplications			$13,830,739				$11,455,715		

West Virginia.

Bromine	pounds			(a)	(a)			130,397	$196,388
Calcium chloride	short tons			3,025	$20,790			4,559	25,754
Cement	barrels			(a)	(a)			(a)	(a)
Clay products	short tons	67,265	b $53,545		5,761,411	85,103	b $59,610		6,284,527
Coal	do	71,707,626	71,391,408			77,184,069	74,561,349		
Coke	do			1,427,962	b 2,847,284			1,391,446	b 2,760,805
Grindstones					(a)				(a)
Iron ore	long tons	(a)	(a)						
Iron, pig	do			(a b)	(a b)			(a b)	(a b)
Lime	short tons			192,195	680,065			250,000	896,520
Mineral waters	gallons sold	307,890	49,129			314,909	50,271		
Natural gas			35,076,755				36,424,263		
Petroleum	barrels	9,680,033	18,468,540			9,264,798	14,468,278		
Salt	do			145,429	78,036			232,239	115,143
Sand and gravel	short tons	1,106,742	590,391			723,354	479,685		
Silica (quartz)	do	(a)	(a)						
Stone			(d)		d 921,208		(d)		d 1,047,695
Miscellaneous			51,020		2,366,190				3,001,931
Total value, eliminating duplications			$133,633,229				$135,111,280		

a Value included under "Miscellaneous."
b Value not included in total value.
c Exclusive of pottery, value for which is included under "Miscellaneous."
d Raw product included under derived product.
e Figures not available.

Mineral production of the United States in 1914 and 1915, by States—Continued.

Wisconsin.

Product.	1914				1915			
	Raw.		Derived.		Raw.		Derived.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Briquets, fuel.....short tons			(a b)	(a b)			(a b)	(a b)
Clay products.....do	646	b $1,149		$950,999	310	b $413		$910,558
Coke.....do			(a b)	(a b)			(a b)	(a b)
Copper.....pounds			10,300	1,370				
Graphite, amorphous.....short tons	(a)	(a)			(a)	(a)		
Iron ore.....long tons	591,595	1,178,610			1,125,269	2,188,012		
Iron, pig.....do			250,944	b 3,350,199			302,913	b 3,997,940
Lead.....short tons			1,494	116,532			2,322	218,268
Lime.....do			227,469	871,820			221,147	755,986
Manganiferous ore.....long tons	c 154,653	(c)			c 181,665	(c)		
Mineral paints:								
Natural pigments.....short tons			2,339	23,390			4,017	53,547
Zinc and lead pigments.....do			(a)	(a)			(a)	(a)
Mineral waters.....gallons sold	5,145,452	588,373			4,861,734	1,051,405		
Pyrite.....long tons	14,188	78,460			13,985	43,354		
Sand and gravel.....short tons	3,594,336	768,996			2,862,036	689,915		
Sand-lime brick				86,682				94,064
Silica (quartz).....short tons	(a)	(a)			(a)	(a)		
Silver.....fine ounces (troy)			16	9				
Stone		(d)		d 2,516,156		(d)		d 2,412,741
Zinc.....short tons			31,113	3,173,526			41,403	10,267,944
Miscellaneous		59,187		3,662,193		36,032		3,969,658
Total value, eliminating duplications	$11,140,365				$19,778,071			

Wyoming.

Clay products.....short tons	(a b)	(a b)		$64,942	(a b)	(a b)		$57,021
Coal.....do	6,475,293	$10,033,747			6,554,028	$9,555,804		
Copper.....pounds			17,421	2,317			447,246	78,268
Gems and precious stones				356				(a)
Gold.....fine ounces (troy)			242	5,006			706	14,592
Gypsum.....short tons	31,216			86,196	38,827			103,110

Iron ore	long tons	(a)	(a)			434,513	(a)	
Lime	short tons							(a) (a)
Mineral waters	gallons sold	69,658	8,802			68,584	9,059	
Natural gas			(a)				(a)	
Petroleum	barrels	3,560,375	1,679,192			4,245,525	2,217,018	
Phosphate rock	long tons	(a)	(a)			(a)	(a)	
Platinum and allied metals	fine ounces (troy)							(a) (a)
Sand and gravel	short tons	718,914	48,595			526,837	49,439	
Silver	fine ounces (troy)			116	64			840 426
Stone			(d)		d 62,331		(d)	d 70,576
Sulphur	long tons	(a)	(a)			(a)	(a)	
Miscellaneous			427,764				546,139	8,261
Total value, eliminating duplications			$12,417,752				$12,708,238	

a Value included under "Miscellaneous."
b Value not included in total value.
c Quantity and value included in iron ore.
d Stone sold rough included under derived product.

PREFATORY NOTE TO THE REPORTS ON GOLD, SILVER, COPPER, LEAD, AND ZINC.

By H. D. McCaskey.

In the mining industry five metals are closely related in both the genesis and the geologic occurrence of their ores. They also hold together in mining and in metallurgical treatment. They are gold, silver, copper, lead, and zinc. Of their ores some contain all five metals, many contain three or four, and few contain only one. Gold and silver, for instance, on the one hand, and lead and zinc, on the other, almost always stand in close genetic relations, and the ores of each two are usually mined together. Copper ores almost invariably produce some silver and gold as well as copper, and lead ores, with certain exceptions, produce notable supplies of silver. Zinc ores in the Western States contribute also to the silver production. In the same mine sometimes, and in the same mining district frequently, all five metals occur in commercial quantity.

This situation is recognized by the United States Geological Survey in its publication of the annual reports on the mineral resources of the country. Hence the general treatment of each of the five metals in the general reports and the grouping together of the related metals in the various mines reports descriptive of individual or geographically grouped States.

To facilitate advance publication, the complete report upon these five metals is therefore divided into 16 sections, each of which is published separately. The first four sections give figures of output for the calendar year in marketable form for the metals named as obtained from the smelters, refineries, and mints, and general reviews of the respective industries for the entire country. The last 12 sections give the production (called "mine production") as obtained from the mines so far as possible in terms of recoverable metal in ores and other material sold or treated during the calendar year, and supply information in detail relative to the mining industry in the respective States, counties, and mining districts. The figures given in the general reports are the final official statistics of production for the country and of the States. The general report on gold and silver includes the statistics of recovered precious metals as determined jointly by the Bureau of the Mint and the United States Geological Survey.

The 16 sections, which appear as separate chapters in this volume, are as follows:

Gold and silver (general report).
Copper (general report).
Lead (general report).
Zinc (general report).
Gold, silver, copper, lead, and zinc in the Eastern States (mines report).
Silver, copper, lead, and zinc in the Central States (mines report).
Gold, silver, and copper in Alaska (mines report).
Gold, silver, copper, lead, and zinc in Arizona (mines report).
Gold, silver, copper, lead, and zinc in California and Oregon (mines report).
Gold, silver, copper, lead, and zinc in Colorado (mines report).
Gold, silver, copper, lead, and zinc in Idaho and Washington (mines report).
Gold, silver, copper, lead, and zinc in Montana (mines report).
Gold, silver, copper, lead, and zinc in Nevada (mines report).
Gold, silver, copper, lead, and zinc in New Mexico and Texas (mines report).
Gold, silver, copper, and lead in South Dakota and Wyoming (mines report).
Gold, silver, copper, lead, and zinc in Utah (mines report).

In measurements of ores, concentrates, and similar material, the short ton of 2,000 pounds is used throughout. The ore classification is necessarily arbitrary in part. An ore is generally understood to be worked at a profit for one or more metals. The complex nature of western ores, especially, and the gradations from one well-recognized class to another render essential some fixed measures for the terminology used. The dry or siliceous ores comprise gold and silver ores proper, as well as fluxing ores carrying considerable quantities of iron and manganese oxides and very small quantities of gold and silver, and also precious metal bearing ores carrying copper, lead, or zinc in quantities too low to classify them as copper, lead, zinc, or mixed ores. The copper ores include those carrying over 2½ per cent of copper, or even less in the cases of the great disseminated copper deposits of the West and of the copper ores of the Lake Superior region. In general, the lead ores are those containing over 4½ per cent of lead, and the zinc ores are those containing 25 per cent or more of zinc, both irrespective of their precious-metal content; but some ores of lower grade in lead, and especially in zinc, are treated profitably for these metals, and of course they are then classified as lead or zinc ores, as the case may be. The mixed ores are combinations of the ones enumerated.

The price per unit of metal production (gold excepted, which is fixed by law at $20.67+ per fine ounce) is based upon averages of daily market prices current at New York for silver, copper, and lead, and at St. Louis for metallic zinc or spelter. The prices used by the United States Geological Survey for calculation of values for the years 1850–1915, inclusive, are as follows:

Prices of silver, copper, lead, and zinc, 1850–1915.

Year.	Silver.[a]	Copper.[b]	Lead.[c]	Zinc.[d]	Year.	Silver.[a]	Copper.[b]	Lead.[c]	Zinc.[d]
	Fine oz.	*Pound.*	*Pound.*	*Pound.*		*Fine oz.*	*Pound.*	*Pound.*	*Pound.*
1850	$1.32	$0.22	$0.05	.....	1883	$1.11	$0.165	$0.043	$0.045
1851	1.34	.166	.05	.....	1884	1.11	.13	.037	.044
1852	1.33	.22	.05	.....	1885	1.07	.108	.040	.043
1853	1.35	.22	.06	$0.055	1886	.99	.111	.046	.044
1854	1.35	.22	.06	.....	1887	.98	.138	.045	.046
1855	1.34	.27	.07	.....	1888	.94	.168	.044	.049
1856	1.34	.27	.066	.....	1889	.94	.135	.039	.05
1857	1.35	.25	.06	.....	1890	1.05	.156	.045	.055
1858	1.34	.23	.06	.....	1891	.99	.128	.043	.05
1859	1.36	.22	.055	.....	1892	.87	.116	.041	.046
1860	1.35	.23	.056	.....	1893	.78	.108	.037	.04
1861	1.33	.22	.05	.....	1894	.63	.095	.033	.035
1862	1.35	.22	.06	.....	1895	.65	.107	.032	.036
1863	1.345	.34	.06	.....	1896	.68	.108	.03	.039
1864	1.345	.47	.07	.139	1897	.60	.12	.036	.041
1865	1.337	.392	.066	.....	1898	.59	.124	.038	.046
1866	1.339	.342	.07	.....	1899	.60	.171	.045	.058
1867	1.33	.254	.065	.....	1900	.62	.166	.044	.044
1868	1.326	.23	.065	.....	1901	.60	.167	.043	.041
1869	1.325	.242	.06	.....	1902	.53	.122	.041	.048
1870	1.328	.212	.06	.....	1903	.54	.137	.042	.054
1871	1.325	.241	.06	.....	1904	.58	.128	.043	.051
1872	1.322	.356	.064	.....	1905	.61	.156	.047	.059
1873	1.297	.280	.06	.....	1906	.68	.193	.057	.061
1874	1.278	.220	.06	.....	1907	.66	.20	.053	.059
1875	1.24	.227	.058	.07	1908	.53	.132	.042	.047
1876	1.16	.21	.061	.072	1909	.52	.13	.043	.054
1877	1.20	.19	.055	.06	1910	.54	.127	.044	.054
1878	1.15	.166	.036	.049	1911	.53	.125	.045	.057
1879	1.12	.186	.041	.052	1912	.615	.165	.045	.069
1880	1.15	.214	.05	.055	1913	.604	.155	.044	.056
1881	1.13	.182	.048	.052	1914	.553	.133	.039	.051
1882	1.14	.191	.049	.053	1915	.507	.175	.047	.124

[a] Report of Director of the Mint, pp. 212-213, 1914. Equivalent value of fine ounce based on average price and average rate of exchange.

[b] Weed, W. H., Copper handbook, vol. 11, pp. 1339, 1343, for years 1850–1903. By computation from data for years 1850–1860, p. 1339. Survey computations for electrolytic copper since 1904.

[c] New York price, Ingalls, W. R., Lead and zinc in the United States, p. 203, 1908. U. S. Geological Survey since 1904.

[d] New York price, 1875–1904, Ingalls, W. R., Lead and zinc in the United States, p. 342, 1908. St. Louis price, U. S. Geological Survey since 1904. The zinc price for 1915 is average sales price for spelter. Oral communication from C. E. Siebenthal for 1853 and 1864.

It is to be understood, of course, that market values are not received by producers for metals in ore and intermediate products, nor always for metals in marketable form, that payment is made in accordance with contracts for treatment or sale, and that, therefore, average daily quotations do not necessarily agree with average prices received.

Each of the 16 sections mentioned is published in a separate pamphlet for advance distribution, and copies can be obtained, as long as the supply lasts, on request made to the Director, United States Geological Survey, Washington, D. C.

CHROMIC IRON ORE.

By J. S. Diller.

PRODUCTION.

The production of chromic iron ore or chromite[1] in the United States in 1915 amounted to 3,281 long tons, valued at $36,744, a gain of 2,690 tons and of $28,029 over 1914. From 1880 to 1915, inclusive, the average annual production has been 1,229 tons, and the average price per ton has been $14.82.

The output in 1915 came entirely from California, and by far the greater part from Shasta and Fresno counties. The other counties in which it was mined, whether sold or not, are Butte, Del Norte, Glenn, Nevada, Tehama, and Tuolumne.

California is justly entitled to be called the "chromite State," for it not only has long supplied the entire domestic output but contains large undeveloped resources. If the increasing demand continues and facilities for transportation to market are developed and cheapened the production is likely to increase. The smallness of the ore bodies and their general low grade have tended to retard development.

PRICES.

The supply of chromic iron ore, chiefly foreign, has been very uncertain and the prices generally have risen. The contracts made before the European war began have been entirely suspended, and ore is now being imported only at prices to be determined by current freight rates. A fair price for imported ore in December, 1915, was $25 to $35 a ton for 50 per cent ore in full cargoes of about 7,500 tons. The retail prices ran as high as $45 a ton, and one lot of 2 tons was imported at $125 a ton. This was ground and packed in casks.

The price at which chromic iron ore was sold on the Pacific coast during 1915 ranged from $11 to $18 a ton f. o. b. cars at point of shipment. On ore that contains more than 50 per cent chromic oxide a premium of 50 cents a ton is paid for each additional per cent unit of chromic oxide. The silica permissible in 50 per cent ore is limited to 8 per cent, and a penalty of 50 cents a ton is imposed for each additional unit in excess of that quantity.

[1] "Chromic iron ore," "chromite," and "chrome ore" are used synonymously in this paper.

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On January 11, 1916, the Southern Pacific Co. announced a reduction in freight rates on ores of manganese and chromium. A rate was fixed at 55 cents a hundred in carload lots from points in California to points east of Chicago and west of the Atlantic seaboard. This rate should enable the producers of chromite in California to compete in the eastern markets. The old rate ranged from 68 to 75 cents a hundred.

The price of bichromate of soda on January 1, 1915, was 4¾ to 5 cents a pound, varying with the quantity, and for bichromate of potash about 10 cents a pound. There has been a continuous advance in the price of these commodities since the spring of 1915, caused by the increase in the prices of raw materials and the uncertainty of receiving them and also by the unprecedented demand for bichromates, a demand due to the unusual conditions abroad. Domestic manufacturers are shipping bichromates freely to foreign countries, and owing to the lack of coal-tar dyes there is a large temporary increase in the use of bichromates in the textile industry at home.

The price of chrome brick fluctuated during 1915 from $50 to $90 a thousand for standard sizes, and on account of freight is usually $2.50 to $3 a ton higher at inland cities than at the seaboard.

IMPORTS.

The total imports of chromic iron ore in 1914 were 74,686 long tons, the maximum since 1908, valued at $655,306. The imports in 1915 as compared with those in 1914 increased 1,769 long tons in quantity and $124,755 in value, so that the average price per long ton increased from $8.77 to $10.20 in 1915.

Chromic iron ore imported in 1914 and 1915.

[Figures furnished by Bureau of Foreign and Domestic Commerce, U. S. Dept. Commerce, Feb. 28, 1916.]

	1914			1915		
	Quantity (long tons).	Value.	Price per ton.	Quantity (long tons).	Value.	Price per ton.
Canada	533	$9,283	$17.42	10,087	$117,302	$11.63
England	58	717	12.36	2	250	125.00
Greece	8,155	73,058	8.96	4,305	52,376	12.17
British South Africa	.....	.....	.....	22,800	277,388	12.17
French Oceania	30,860	201,907	6.54	28,031	177,125	6.32
Portuguese Africa	23,200	282,257	12.17	11,230	155,620	13.86
Turkey in Asia	11,880	88,084	7.41	.....	.....	.....
Total	74,686	655,306	8.77	76,455	780,061	10.20

Chromium compounds imported for consumption, calendar year 1915.[a]

	Quantity.	Value.	Price per unit.
Chromic iron ore ..... long tons..	76,455	$780,061	$10.20
Chromic acid ..... pounds..	3,571	755	.211
Chromate and bichromate of potash ..... do....	32,942	2,902	.088
Chrome or chromium and ferrochrome or ferrochromium.. long tons..	32	1,662	51.94

[a] U. S. Dept. Commerce, Mar. 20, 1916.

CHROMIC IRON ORE IN NORTH AMERICA.

CALIFORNIA.

California is the banner State in deposits and production of chromic iron ore. The ore occurs in at least 25 counties of the State and properties are being operated in 8 counties,[1] namely, Butte, Del Norte, Fresno, Glenn, Nevada, Shasta, Tehama, and Tuolumne. Much has been said in previous reports[2] concerning these deposits and need not be repeated here.

Butte County.—The Zenith Chrome Mining Co., of Oakland, Cal., operated in 1915 a newly developed group of claims near Forbestown, in Butte County. By means of a motor truck a carload of ore was hauled 25 miles to Oroville and shipped east. The ore body is in serpentine and is about 25 feet thick. Other outcrops occur in the same neighborhood, and mining will be pushed as soon as the weather permits. The ore shipped is said to have been of rather low grade. It yielded between 40 and 50 per cent cent of chromic oxide and contained about 3 per cent of silica.

Calaveras County.—The great serpentine belt that extends northwestward through Calaveras and adjoining counties was mapped by H. W. Turner,[3] who pointed out and briefly described the chrome deposits in the neighborhood of Valley Springs. These deposits have recently been visited by W. B. Tucker, of the State Mining Bureau of California, who reports[4] more particularly concerning the deposits on the Vogelsang ranch, about 5 miles southeast of Valley Springs, where a series of six lenses of chromic iron ore occur in serpentine within a distance of 700 feet along the strike of the beds (N. 45° W.). The largest lens is about 50 feet long and 10 feet wide. The lenses are nearly vertical or dip to the southeast. They occur in the serpentine, 25 feet from its contact with the amphibole schist, and lie nearly parallel with the contact. The deposit, which is owned by Charles Vogelsang and W. Ellingwood and is not far from the Vogelsang ranch, has recently been bonded to G. G. Fraser, but no production was reported in 1915. An average of several analyses of the ore furnished by the owners shows that it contains more than 41 per cent of chromic oxide.

Del Norte County—The Tyson mines, in Del Norte County, have been idle for many years. Other claims have recently been taken up, and some ore has been mined but none was sold. The discovery of a chrome deposit on Elk Creek, in Siskiyou County, has been announced.

Fresno County.—Fresno County became an active producer in 1915. The principal producer, one of the largest in the country, is the Levensaler-Speir Corporation, of San Francisco. M. L. Curtis & Co., who work a deposit 6 miles northeast of Piedra (Wahtoke?), ship a carload every two or three weeks. The ore contains 40 to 45 per cent chromic oxide.

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[1] For much of the information concerning the recent activities in chromite mining in California I am indebted to Mr. Samuel Dolbear, a mining engineer of San Francisco.—J. S. D.

[2] See chapters on chromic iron ore in U. S. Geol. Survey Mineral Resources, 1908 to 1914, inclusive. See also annual reports of the California State Mineralogist and chapters of biennial report for 1913–14, as well as Bulletin 38 of the California State Mining Bureau.

[3] U. S. Geol. Survey Geol. Atlas, Jackson folio (No. 11), 1894.

[4] California State Min. Bur., Mineralogist's Rept. 1913–14, Calaveras County, pp. 55, 56, 1915.

The Manganese Co. of California, whose headquarters are in San Francisco, has leased one of the Levensaler-Speir deposits, 10 miles north of Piedra, and is mining ore in Fresno County and at the same time carrying on development work in Nevada County.

Glenn County.—A number of chromite prospects in Glenn County, owned by W. R. Chesley, Guy M. Luce, and Alonzo Luce, have recently been sold to the California Chrome Co., of San Francisco.

Placer County.—Lindgren reports irregular masses of chromite in serpentine near the North Fork of American River, below Towle.[1] Fine specimens of coarsely crystalline sheared chromite have recently been sent to the United States Geological Survey from this locality by C. H. Sherman. They are reported to contain about 54 per cent chromic oxide.

Shasta County.—The L. H. Brown mine, which has been for a number of years the principal producing chrome mine in the United States, was sold to the California Chrome Co., consisting of J. B. Huffard, president, Clarence M. Oddie, manager, and others of San Francisco. The property includes four claims, called the Summit, Sunflower, Castle Crag, and Blue Jay, located in 1906 and 1908 on Little Castle Creek near Dunsmuir, chiefly in Shasta County but partly in Siskiyou County. Mr. Brown operated the mine to July 23, 1915, when it was taken over by the company. Its production for the year 1915 was much greater than ever before. This mine was described in some detail in this report for 1913 and 1914.

Tehama County.—The Noble Electric Steel Co. is making improvements in its electric furnace at Heroult, on Pit River, in Shasta County, in preparation to increase its output of ferromanganese and ferrochrome. A considerable production of chrome ore has been taken out at the mine of this company at Lowrey, Tehama County, but the ore has not been shipped.

Tulare County.—It is stated that large outcrops of chromic iron ore lie 5 miles southeast of Portersville on the lands of D. A. Vaughn, from which a carload was shipped about 20 years ago. Reports indicate that the ore contains over 50 per cent of chromic oxide. There was no production in 1915, but the property has been leased and contracts have been entered into for production in the near future.

Tuolumne County.—The California Chrome Co. is reported to have purchased a mine near Jamestown, Tuolumne County, from which considerable chromic iron ore was shipped in 1915. The ore averaged from 40 to 45 per cent chromic oxide and 6 per cent silica.

Peter Mackey, of Jamestown, is a producer in the same region.

ALASKA.

In Kenai Peninsula, Alaska, on Red Mountain, about 10 miles southeast of Seldovia, a number of claims have been located on a deposit of chromic iron ore described in a recent report,[2] which gives also an analysis of the ore. Its high content of chromic oxide and its nearness to tidewater suggest that it may be of commercial value.

[1] Lindgren, Waldemar, U. S. Geol. Survey Geol. Atlas, Colfax folio (No. 66), 1900.
[2] Grant, U. S., The southeastern coast of Kenai Peninsula: U. S. Geol. Survey Bull. 587, pp. 237–238, 1915.

CANADA.

During the last six months of 1915 some 10,000 tons of chromic iron ore, containing probably 30 per cent chromic sesquioxide, was exported from Black Lake and Coleraine, Quebec.[1]

A report[2] issued more recently gives the production of Canada for 1915 as 14,291 short tons, valued at $208,718. During the summer months ore averaging less than 30 per cent chromic oxide found a ready market, but toward the end of the year buyers were insisting on a 35 per cent ore. By far the greater part of the ore (10,087 long tons) came to the United States at an average price of $11.63 a ton.

FOREIGN PRODUCTION OF CHROMITE.

The disturbed condition of Europe, though it stimulated the production of chromic iron ore, greatly interfered with its commercial distribution. Detailed information of foreign production is not available. The principal sources of the ore in recent years have been Rhodesia and New Caledonia.

In Rhodesia, British South Africa, the output for the first 11 months in 1915 is reported[3] as 57,333 long tons. If the monthly average production was kept up during December the output for the year was 62,545 tons.

In New Caledonia the output of chromite[4] in 1915 appears to have been about 67,000 tons; that in 1914 was 42,000 tons. There are now blast furnaces at Noumea and Thio, and hydroelectric plants at Tate and Tao.

Russia appears to be the next largest producer. Its output[5] in 1912 was 20,934 tons. Later statistics are not available.

The production of chromic iron ore in India has increased in late years. In 1914 it was 5,888 long tons.[6] Leather tanning with chromium salts is a thriving industry in southern India.[5]

Greece, Turkey, and Japan produce some chromite, but the annual output of each does not exceed a few thousand tons.

USES OF CHROMIUM.

Chromic iron ore is used in the manufacture of ferrochrome and steel for high-speed tools, armor plate, and projectiles, and in the manufacture of bichromates of soda and potash, chromic acid, chrome alum, and chrome tannage.

RECENT PUBLICATIONS CONCERNING CHROMIUM.

Browne, De Courcy, Metals and alloys in the steel industry: Iron Age, Jan. 6, 1916, p. 23. States that "chromium is a very important alloying metal in tool steels and in automobile and other special steels. It is produced electrolytically and by the thermite process in this country. The highest grades of ores are imported principally from Turkey, New Caledonia, and the Ural Mountains of Russia; also large deposits occur in Canada and the Far West, but owing to the difficulties in transportation only small amounts of ores have been brought in from the first two sources."

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[1] Denis, T. C., Canadian Min. Jour., Jan. 1, 1916, p. 9.
[2] McLeish, John, Preliminary report on the mineral production of Canada during the calendar year 1915, p. 18, Mines Branch, Dept. Mines, Ottawa, Canada.
[3] Min. Jour. [London], Jan. 1, 1916, p. 12.
[4] Min. Jour. [London], Jan. 15, 1916, p. 47.
[5] London Chamber of Commerce Jour., Jan., 1916, pp. 9–10.
[6] Geol. Survey India Records, vol. 45, pt. 3, p. 161, 1915.

He notes that the price of chromium has advanced about 50 per cent, but that a sufficient quantity seems to be available to supply the demands, although prices are higher than ever before.

CULLEN, J. F., KEENEY, R. M., and LYON, D. A., The electric furnace in metallurgical work: U. S. Bur. Mines Bull. 77, pp. 127–141, 1914. Gives an account of the smelting of chromite and the manufacture of ferrochrome, as well as its uses and prices in 1912 and 1913.

HADFIELD, Sir ROBERT, The corrosion of high-chromium steels: Iron Age, Jan. 20, 1916, p. 202. A paper read before the Faraday Society of England, Dec. 8, 1915.

HALL, EDGAR, Chrome-iron ore as lining for reverberatory furnaces: Eng. and Min. Jour., Feb. 5, 1916, p. 267. Describes in detail the dry-masonry lining method successfully applied in Australia, giving special attention to difficulties in practice.

HAYNES, ELWOOD, Stellite, a cobalt-chromite alloy of great hardness: Eng. and Min. Jour., Oct. 30, 1915, p. 711.

NORRIS, G. L., Alloy steels: Canadian Min. Jour., Jan. 15, 1916, p. 44. Says that chromium steel containing about 1 per cent each of carbon and chromium is used principally in balls and ball bearings. It is used also in stamp-mill shoes and, combined with soft steel, in laminated plates for burglar-proof safes and jail bars.

There are three alloys of nickel-chromium steel, which differ in their percentage of nickel and chromium and contain little carbon. The percentage of the three metals in these alloys are shown below:

	Nickel.	Chromium.	Carbon.
1.....	3.5	1.50	0.25–0.45
2.....	2.0	1.00	.10
3.....	1.5	.50	.10

The first alloy came into use about 1895 and is employed in armor plates and armor-piercing projectiles. The other two have been developed by the automobile industry. The third is largely used in making all-round engineering steel.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN THE EASTERN STATES.

(MINES REPORT.)

By James M. Hill.

INTRODUCTION.

This section of the Mineral Resources report deals primarily with the mines of the Eastern States from which gold, silver, copper, lead, and zinc were produced in 1915. For convenience in the collection of statistics the zinc and copper mines of eastern Tennessee are grouped with the Eastern States.

Most of the mines discussed in this chapter are situated on ore deposits contained in metamorphic rocks that are of pre-Cambrian age, which have been intruded by both basic and igneous rocks. This belt of rocks extends from eastern Alabama in a northeasterly direction to Canada. It is wide in northern Georgia, western South Carolina, and in central North Carolina and Virginia; but it narrows in Maryland, Pennsylvania, and New Jersey, only to open again into a broad belt in the New England States. It is bounded on the northwest by the Paleozoic rocks of the Blue Ridge and its northward continuations, and on the southeast by the sedimentary rocks of Cretaceous and younger age, which make up the Coastal Plain series. The copper, lead, and zinc deposits of eastern Kentucky and Tennessee and western Virginia are found in Paleozoic rocks, and by far the greater number are in the Knox dolomite, of Cambrian and Ordovician age. In part of the area the beds are in a nearly horizontal position, but at other places are closely folded and faulted.

The zinc deposits of northern New York are found in crystalline limestones associated with gneisses and schists, all of which are presumably of pre-Cambrian age.[1]

MINE PRODUCTION.

The total value of the output of gold, silver, copper, lead, and zinc in the Eastern States was $25,151,220 in 1915, a notable increase of $13,713,513, or nearly 120 per cent, over the production in 1914. The total value is distributed among the various metals as follows: Gold, $224,250; silver, $51,990; copper, $3,285,229; lead, $32,775; zinc, $21,556,976.

As will be seen from the following table, the great increase in value is due largely to the increased output of the zinc mines, and, of course, to the increase in price of all the metals except gold and silver.

[1] Smyth, C. H., On the genesis of the pyrite deposits of St. Lawrence County: New York State Mus. Bull. 158, pp. 143–183, 1912.
Newland, D. H., Zinc ore in northern New York: Eng. and Min. Jour., pp. 1094–1095, June 9, 1906.

Mine production of metals in the Appalachian States, 1914–1915.

Year.	Ore sold or treated.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	1,842,890	$173,589	100,727	19,555,362	254,000	169,716,954	$11,437,707
1915	2,215,538	224,250	102,545	18,772,735	697,329	273,650,575	[a]25,151,220
Increase or decrease	+372,648	+50,661	+1,818	−782,627	+443,329	+103,933,621	+13,713,513

[a] In calculating the total value of metals the value of zinc is less than would be the case were it all calculated as spelter at the average spelter sales price of $0.124 a pound. This difference is due to the fact that the zinc ore produced in New Jersey is not all used for the manufacture of spelter and is, therefore, calculated on a basis which gives it a valuation of zinc oxide and spelter.

GOLD.

There were 10,848.09 fine ounces of gold produced in the Eastern States in 1915, having a total value of $224,250. Of this output the placers yielded 1,163.41 ounces, the siliceous gold ores 9,349.54 ounces, and copper ores 335.14 ounces, all of which showed an increase over the production of 1914. As will be seen from the first table below, there were large increases in Georgia and North Carolina, small increases in Tennessee and Virginia, small decreases in Maryland and Pennsylvania, and large decreases in Alabama and South Carolina.

SILVER.

In 1915 there were produced in the Eastern States 102,545 fine ounces of silver, valued at $51,990. The largest production was from copper ores and the smallest from placer mines, as is shown by the second table below. Although the quantity of silver increased 1,818 ounces over the production in 1914, the value decreased by $3,712. There was a slightly larger production of silver in Georgia, Vermont, and New Hampshire, but in all the other States the production was below that of 1914.

Mine production of gold and silver in the Eastern States in 1915.

State.	Gold.		Silver.		Increase or decrease in value compared with 1914.	
	Quantity.	Value.	Quantity.	Value.	Gold.	Silver.
	Fine ounces.		*Fine ounces.*			
Alabama	253.63	$5,243	12	$6	−$6,727	− $104
Georgia	1,732.84	35,821	138	70	+19,551	+ 33
Maryland and Pennsylvania					− 225	− 24
North Carolina	8,320.55	172,001	1,465	743	+40,860	− 100
South Carolina	183.29	3,789	8	4	− 3,571	− 14
Tennessee	331.95	6,862	100,543	50,975	+ 668	−2,889
Vermont and New Hampshire			379	192		+ 192
Virginia	25.83	534			+ 105	− 806
	10,848.09	224,250	102,545	51,990		
Increase or decrease in 1915	+2,450.73	+50,661	+1,818	−3,712	+50,661	−3,712

Source of mine production of gold and silver in the Eastern States in 1915, in fine ounces.

State.	Gold.			Silver.		
	Placers.	Dry or siliceous ores.	Copper ores.	Placers.	Dry or siliceous ores.	Copper ores.
Alabama	2.85	250.78	.....	2	10	.....
Georgia	738.06	994.78	.....	39	99	.....
Maryland and Pennsylvania	.....	.....	.....	.....	.....	.....
North Carolina	410.51	7,910.04	.....	51	1,414	.....
South Carolina	11.99	171.30	.....	.....	8	.....
Tennessee	.....	.....	331.95	.....	.....	100,543
Vermont and New Hampshire	.....	.....	.....	.....	.....	379
Virginia	.....	22.64	3.19	.....	.....	.....
Total, 1915	1,163.41	9,349.54	335.14	92	1,531	100,922
Total, 1914	904.56	7,165.59	327.21	62	1,737	98,928

COPPER.

The production of copper in the Eastern States in 1915 was 18,772,735 pounds, valued at $3,285,229, which was less than the production in 1914 by 782,627 pounds. This copper was largely derived from Tennessee ores, but some came from the copper-bearing magnetite ores of Pennsylvania, and small quantities from copper ores mined in North Carolina, Vermont, and Virginia. The total quantity of ore treated to produce this copper was 868,555 tons, showing a copper yield of approximately 1 per cent or 20 pounds a ton. This low yield can be accounted for by the fact that a large part of the tonnage represents iron ores which contain little copper. Some ores shipped from Virginia carried as much as 10 per cent copper, and the Tennessee ores carried approximately 2 per cent copper.

LEAD.

The production of lead in the Eastern States in 1915 was 697,329 pounds, valued at $32,775. The great bulk of this production was from Virginia, but small quantities were produced in New Hampshire, Pennsylvania, and Tennessee.

ZINC.

The production of zinc in the Eastern States in 1915 was 273,650,575 pounds, valued at $21,556,976, an increase of 103,933,621 pounds over the production in 1914. It will be noticed that this value is less than it would be if the zinc content of the ore were figured as spelter at 0.124 cent a pound. The difference is because of the fact that the zinc ore mined in New Jersey is not all used for the manufacture of spelter, and its value is, therefore, calculated on a basis which gives a more nearly true value of the zinc oxide and spelter produced.

New Jersey produced more zinc than all the remaining States, and Tennessee was second with a production of nearly 33,000,000 pounds. New York and Virginia were next in rank with a production of approximately 5 and 2.5 million pounds.

REVIEW BY STATES.

ALABAMA.

In 1915 there was mined in Alabama 253.63 ounces of gold, valued at $5,243, and 12 ounces of silver, valued at $6.

Mine production of gold and silver in Alabama, 1914–15.

Year.	Number of mines.		Ore sold or treated.	Gold.[a]	Silver.[a]	Total value.
	Placer.	Deep.				
			Short tons.		*Fine ozs.*	
1914	1	2	5,079	$11,970	199	$12,080
1915	2	1	1,250	5,243	12	5,249
Increase or decrease in 1915	+1	−1	−3,829	−6,727	−187	−6,831

[a] Includes placer gold and silver.

The decrease is due to the closing of the Hog Mountain mines, in Tallapoosa County, which for several years produced most of Alabama's gold and silver. There was very little placer mining during 1915, only a nominal output of placer gold being reported to the Survey. Some prospecting was done on the placer deposits near Arbacoochee, in Cleburne County, but it resulted in no extensive development. The dredge installed there two years ago has been dismantled. Near Chula Finne there was some prospecting for gold quartz. Placer gold was found in a branch on the Tucker farm, 2 miles east of Heflin, and a little sluicing was done in June. The Story mine in Talladega County was operated by the Gold Log Mining Co. The ore is treated in a 10-stamp amalgamating mill.

In the vicinity of Arbacoochee the old placer workings covered a narrow area about 3 miles from east to west along Mud Creek. Much of the work done was on shallow, hillside wash. The material worked was angular quartz carried in a red clay; it is entirely local. The gold in the form of irregular angular nuggets and flakes was evidently derived from the numerous small quartz stringers in the saprolitic schists, and the concentration was practically in place. A little gold was carried into the bed of Mud Creek, which has been worked to the junction with Clear Creek. Clear Creek, so far as could be learned, has not been prospected, though it heads in Turkey Heaven Mountain, in which there are known to be auriferous lodes. It would seem that the saprolite deposits east of Arbacoochee should be tested and that drilling in the angular quartz gravels of Clear Creek, both above and below the mouth of Mud Creek, might reveal workable dredge ground. Above the mouth of Mud Creek the Clear Creek gravels appear to be relatively thin, ranging from 3 to 8 feet thick; below the mouth of Mud Creek the valley widens to about 1 mile and the gravels appear to be deeper. It is said that at the dredge there was 16 feet of gravel and most of the gold was concentrated in the lower 2 or 3 feet. Angular quartz fragments from 2 to 8 inches in size constitute about 85 per cent of the gravel, the remainder being rather soft schist and slate. This condition is brought about by the soft altered condition of most of the rocks in the vicinity.

GEORGIA.

In 1915 there were produced in Georgia 1,732.84 ounces of gold, valued at $35,821, and 138 ounces of silver, valued at $70. This is the largest output of gold and silver from the State since 1905 when the Survey first began the collection of statistics of the metal output of the Eastern States. Of the 1915 output, placer mining furnished 738.06 ounces of gold and 39 ounces of silver, the remainder coming from deep mines. The output from deep mines is particularly encouraging, as it shows an increase of 741.92 ounces of gold and 61 ounces of silver over 1914. The value of ore treated in 1914 averaged $3 a ton; in 1915 the average yield of precious metals was $1.29 a ton. This decrease in yield is the result of the treatment at Villa Rica and Dahlonega of large quantities of saprolite. This development has apparently demonstrated that the large bodies of low-grade saprolite ore can be successfully worked by the cyanide method alone, or by a combination of the Dahlonega method of sluicing and crushing followed by cyanide treatment.

Mine production of gold and silver in Georgia, 1914–15.

Year.	Number of mines.		Ore sold or treated.	Gold.[a]	Silver.[a]	Total value.
	Placer.	Deep.				
			Short tons.		*Fine ozs.*	
1914	26	11	1,750	$16,270	67	$16,307
1915	31	9	20,052	35,821	138	35,891
Increase or decrease in 1915	+5	−2	+18,302	+19,551	+71	+19,584

[a] Includes placer gold and silver.

As will be seen from the following table, the Dahlonega belt and its southern branch, the Carroll County belt, yield practically the whole output of the State.

Mine production of gold and silver in Georgia, 1915, by counties.

County.	Gold.		Silver.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Fine ounces.		*Fine ounces.*		
Bartow and Cherokee	76.66	$1,585	6	$3	$1,588
Dawson and Milton	25.44	526	.....	.....	526
Forsythe	31.16	644	2	1	645
Haralson, Paulding, and Douglas	823.73	17,028	42	22	17,050
Lumpkin	349.65	7,229	67	33	7,261
McDuffie and Wilkes	32.53	672	.....	.....	672
Rabun and Union	219.38	4,535	8	4	4,539
White	174.29	3,603	13	7	3,610
Total, 1915	1,732.84	35,821	138	70	35,891
Total, 1914	787.06	16,270	67	37	16,307

Bartow and Cherokee counties.—Placer mining resulted in a small production of gold at the McMichen mine near Allatoona, Bartow County, and on Blanket Creek near Holly Springs and also from a number of streams near Canton, in Cherokee County. The old Farrar

mine near Holly Springs was operated by Z. W. Sumerour during the last half of the year. The work was largely experimental and exploratory. A light 3-stamp battery was installed and some gold and silver was recovered.

Dawson and Milton Counties.—The Taytars Creek and McKee placer mines near Dawsonville, Dawson County, were in operation during the year; and on Cowpen Branch near Suwanee, Milton County, some gold was recovered by sluicing.

Forsythe County.—Prospecting in the Appalachee mine near Big Creek resulted in the finding of some gold, and there was a nominal output of placer gold won from various streams near Cumming and East Point.

Haralson, Paulding, and Douglas counties.—The Royal mine near Tallapoosa, Haralson County, was reported idle during the year. The nominal output of gold from this property evidently was the result of prospect work.

The Harper-Johnson mine, 10 miles north of Dallas, in Paulding County, was in operation during the first half of the year, treating saprolitic ore in Snodgrass washers and amalgamating plates. The mine was closed in July, from insufficient water supply.

The Oklahoma Gold Mining Co., a mile west of the Harper-Johnson mine, was operated through an incline drift tunnel run on the vein approximately at water level. The oxidized gold quartz ores are treated in a 5-stamp mill, with Snodgrass washers, and the gold is saved by amalgamation. Sulphide ore is exposed at water level. More extensive development will probably wait the installation of a new method of treatment.

The Pine Mountain mine, 3 miles north of Villa Rica, Douglas County, was extensively developed in 1915. This mine is a consolidation of several properties on which there is a large deposit of sapolitic gold ore. Mining through a glory hole and cyanide treatment of the ore without previous crushing has made it possible to handle this low-grade material with apparent profit. The system is new, so far as the Survey is aware, and a study of the methods developed by Mr. T. H. Aldridge might well repay the owners of the various large deposits of saprolite, whose low-grade ore has been the stumbling block of a number of mining ventures in the South.

Lumpkin County.—The Chestatee Dredge Co. spent several months moving an old dredge to a location below the Briar Patch Bridge, 3 miles south of Dahlonega, and changing to electrical drive. Late in 1915 digging was commenced with apparently successful results, as it is reported that the Bunker Hill Mining Co., owners of the land, will continue operations.

The Findley Ridge Mining Co. opened some rich gold quartz veins in the saprolite deposit covered by the Colombia and Crown Mountain claims. Hydraulic giants are used for breaking the ground, which is transported through a 2-mile flume to a 50-stamp amalgamation mill. Some gold is caught in the sluices and some on amalgamation plates after crushing. It is reported that experiment with cyanide leaching of the tailings has demonstrated the possibility of such treatment.

The Toledo Mining Co. operated the Free Jim saprolite deposit, just north of Dahlonega, by the hydraulic method for several months, during which operations considerable gold was saved.

Munson & Ashton hydraulicked a deposit of wash and gravel below the Calhoun vein, about 3 miles southeast of Dahlonega, with some success, and installed a hydraulic elevator on the Briar Patch placer to test the gravels in the Chestatee bottoms.

The Turkey Hill property north of the Calhoun mine was extensively prospected, and it is reported that the developments were so encouraging that an amalgamation mill will be installed to handle the ore.

The Barlow and Little Findley properties of the Water Power Mining Co. were worked by lessees with some success. A small quartz vein opened in the Barlow yielded gold, and sluicing in the bottom of the cut gave a fair return. A giant on the Little Findley ground was used to hydraulic saprolite to a 5-stamp mill.

McDuffie and Wilkes counties.—At the Latimer mine, 4 miles north of Rayle, Wilkes County, gold was recovered by sluicing from a deposit of high gravel near Dry Fork Creek. A small yield of gold was obtained in prospect work about the mines near Thompson, McDuffie County.

Rabun and Union counties.—Several properties in Rabun County were prospected during the year and a nominal output of placer gold was reported. The Coosa Creek properties near Blairsville, Union County, were not actively exploited.

White County.—The Loud placer deposits, 3 miles northwest of Cleveland, were worked with a hydraulic elevator. Placer gold was also recovered from the White County and Parks properties. According to reports received by the Survey there was considerable prospecting of both quartz and placer deposits in White County.

MAINE.

No metal production was reported from Maine during 1915. It is stated that a concentrator is being installed in the Blue Hill mine, Hancock County, and that mining will begin early in 1916. The Farnsworth mine, Washington County, will probably also begin operations in 1916, as soon as the weather permits.

MARYLAND.

According to reports received by the Survey, no gold or silver was produced in Maryland during 1915. Active prospecting on several properties, notably the Ford tract near Great Falls, Montgomery County, was started during the year under the direction of A. A. Hassan. The tract under development includes the Great Falls and Maryland mines, which were apparently not producers during that part of the year prior to their acquisition by the present holder.

It is understood that three diamond drills are in operation and that a large force of men were employed trenching the land. No definite information is available concerning results of this work, but it is believed that the value of this area, covering apparently 10 square miles, will be determined as a result of this systematic work. Naturally the activity on this property has had an influence on the surrounding territory and a number of farms in the vicinity of Great Falls have been more or less thoroughly prospected, though with what result is not known.

NEW HAMPSHIRE.

There was apparently no active mining in New Hampshire either in Carroll, Coos, or Grafton counties. Silver, lead, and zinc were recovered from concentrates obtained by treating tailings at the West Ossipee mines, Carroll County.

NEW JERSEY.

The production of New Jersey is, as usual, confined to the output of the Mine Hill and Stirling Hill mines at Franklin Furnace, Sussex County. There were 737,310 tons of crude ore produced at these mines in 1915, which yielded a total of 233,236,000 pounds of zinc in zinc oxide and spelter. It should be understood that a comparatively small part of the zinc ore mined at Franklin Furnace is used for the manufacture of spelter. The greater part of this zinc is converted into oxide of zinc at works located in Pennsylvania.

NEW YORK.

The Balmat and Edwards mines, St. Lawrence County, known locally as the Brown and White, from the names of the farms upon which they are located, were actively developed during 1915. The two shafts, about 600 feet apart, are being connected by a drift on the 400-foot level. The new 200-ton mill was completed and was put in operation in March. The ore is broken in a crusher and rolls and concentrated on jigs and tables. A final separation of pyrite and sphalerite in the concentrate is accomplished on Weatherby machines, a combination magnetic separator and reciprocating wet table.

On the Webb farm near Edwards, the Lux Development Co., has installed a hoist and sunk two shafts on a zinc deposit said to be similar to that developed by the Northern Ore Co. Work was discontinued for the winter but will recommence early in 1916.

NORTH CAROLINA.

The gold, silver, and copper produced in North Carolina in 1915 had a value of $175,749, distributed as follows: Gold, 8,320.55 ounces, valued at $172,001; silver, 1,465 ounces, valued at $743; copper, 17,170 pounds, valued at $3,005. Of the gold, about 95 per cent was obtained from siliceous gold ores and the remainder from placer deposits. Of the silver, about 97 per cent came from siliceous gold ores and the rest from placers. The gold ores treated yielded an average of $6.65 a ton in precious metals. The copper was derived from concentrates produced from 4,438 tons of ore mined in Granville, Guilford, and Rowan counties, which yielded approximately 4 pounds of copper per ton of ore concentrated.

Mine production of gold, silver, and copper in North Carolina, 1914–15.

Year.	Number of mines.		Ores sold or treated.	Gold.	Silver.	Copper.	Total value.
	Placer.	Deep.					
			Short tons.		*Fine ounces.*	*Pounds.*	
1914	12	9	19,451	$131,141	1,524	20,434	$134,702
1915	22	7	25,910	172,001	1,465	17,170	175,749
Increase or decrease in 1915.	+10	−2	+6,459	+40,860	−59	−3,264	+41,047

As shown by the following table, Montgomery County produces nearly twice as much as the next largest producer, Rowan County, adjoining it, and these two counties yield approximately 78 per cent of the total output of the State. Most of this production is from siliceous gold ores.

Mine production of gold, silver, and copper in North Carolina, in 1915, by counties.

County.	Gold.		Silver.		Copper.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
Burke, Caldwell, and Catawba	*Fine ounces.* 48.51	$1,003	*Fine ounces.* 10	$5	*Pounds.*		$1,008
Cabarrus	13.59	281	2	1			282
Gaston and Mecklenburg	44.75	925	5	3			928
Granville and Guilford	763.39	15,781	160	81	13,770	$2,410	18,272
Montgomery	4,369.43	90,324	806	409			90,733
Rowan	2,218.83	45,864	218	110	3,400	595	46,569
Rutherford	275.32	5,694	26	13			5,707
Stanley and Union	586,73	12,129	238	121			12,250
	8,320.55	172,001	1,465	743	17,170	3,005	175,749

Burke, Caldwell, and Catawba counties.—At the Brindletown and Pilot Mountain placers at the western end of the South Mountains, Burke County, placer gold was won by hydraulic and ground sluicing operations, the principal yield being from Brindle and Suttewhite creeks.

Prospecting on the property of the Nibelung Gold Mining Co., near Lenoir, Caldwell County, resulted in a small output of gold. What ore was mined has been put into bins for future treatment. None of the other mines in this county reported activity during the year. A nominal output of gold was won by sluicing on the Wheeler Edwards property near Catawba, Catawaba County.

Cabarrus County.—The output from Cabarrus County was entirely from placer mines, notably from the Klutz and the Litaker mines, near Concord, and the Saunders mine, near Bosts Mills.

Franklin County.—There was no production from this county in 1915, but the Portis mine, near Wood, was reopened in September, 1915, and has been extensively prospected by the present owner. It is reported that the property will be worked by steam shovel discharging in rolls crushing to one-eight inch, and that the gold will be saved in sluices.

Gaston and Mecklenburg counties.—The old Catawba mine, south of Kings Mountain, Gaston County, was under development part of the year and produced a small output of gold and silver. One other property east of Kings Mountain also produced a little gold. A discovery of gold ore on the Sandsig farm, east of Kings Mountain, was prospected by several shafts and cuts.

The only production of gold recorded in Mecklenburg County was obtained as a by-product by the Catawba Sand & Gravel Co.'s dredge on the Piedmont placer. It is reported that the dumps of the Mint Hill mine near Mathews will be reworked.

Granville and Guilford counties.—A small test shipment of copper ore was made from the Copper King mine in Granville County, and it is reported that the Blue Wing and Copper King will be operated during 1916.

A shipment of copper ore from the dump of the Gardner Hill mine, near Greensboro, Guilford County, was made for test purposes, and some gold and silver was recovered on the mill plates. It is the intention of the company to install a concentrating plant to treat the dump.

Montgomery County.—The principal operators in Montgomery County are the Martha Washington Mines Co. and the Unarra Mining Co., near Candor, and the Richcog Mines Co. and the Sally Coggins Mining Co., near Eldorado. Several other properties were prospected during 1915 and it would seem that there should be a large production from this district during 1916. A nominal output of placer gold was reported to the Survey, but the production from this county may be considered as derived from siliceous gold ores.

Nash County.—Considerable prospect work was done in Nash County during 1915, and reports from several companies indicate that development work will be done during 1916.

Rowan County.—A nominal output of placer gold was reported from Rowan County. The largest producer was the Gold Hill mine, which was in operation during the first half of the year on siliceous gold ores carrying a small amount of copper, which was saved by concentration. It was reported in August that mining operations had been stopped.

Rutherford County.—Several placer deposits at Golden were worked during 1916, the largest operations being on the Biggerstaff mine at the west end of the valley. At this place hydraulic giants are used against an 11-foot bank, of which approximately 9 feet is overburden. A 2-mile ditch supplies water under a head of 200 feet. The gold is saved in ground sluice and is not much water worn.

The Ten Flat mine was opened late in 1915 and will be worked by hydraulic operations during 1916. This property is on Somey Creek near the junction with First Broad River, a short distance east of Golden. It is reported that some placer ground in the vicinity of Union Mills on Second Broad River will be worked in 1916.

Stanley and Union counties.—A little placer gold was recovered from deposits near New London, Stanley County, and Indian Trail, Union County. The Howie mine near Waxhaw was the largest producer in Union County. In November, 1915, a 300-ton cyanide plant was built at this mine; it uses the Dorr system, which is said to have made an excellent recovery for the siliceous gold ore.

PENNSYLVANIA.

The Cornwall iron mines in Lebanon County produced pyritiferous magnetite ore, from which a copper concentrate is made. A small shipment of lead was reported from Shenango, Mercer County, in the northwestern part of the State.

SOUTH CAROLINA.

In 1915 there was produced in South Carolina 183.29 ounces of gold and 8 ounces of silver, having a total value of $3,793. The placer mines produced 11.99 ounces and the deep mines 171.30 ounces of gold and all the silver. The average yield of the siliceous gold ores and auriferous pyrite mined in 1915 was 70 cents a ton. The gold

quartz ores yielded approximately $15 a ton. This is the smallest production recorded for South Carolina since 1905, when the Survey began the collection of statistics of output in the Eastern States, and is to be accounted for in large part by the fact that the Haile mine was operated largely for pyrite, which contained only a small quantity of gold.

Mine production of gold and silver in South Carolina in 1915.

Year.	Number of mines.		Ore sold or treated.	Gold. [a]	Silver. [a]	Total value.
	Placer.	Deep.				
			Short tons.		*Fine ounces.*	
1914	6	1	7,531	$7,360	33	$7,378
1915	4	3	2,424	3,789	8	3,793
Increase or decrease in 1915	−2	+2	−5,107	−3,571	−25	−3,585

[a] Includes placer gold and silver.

Cherokee County.—As usual, there was a nominal production of placer gold from the property of the Gaffney Land & Improvement Co.

Lancaster County.—At the Haile mine there was a small production of gold derived from prospecting and from pyrite ore, which was sold for its sulphur content. This ore was mined from the 50, 80, and 100 foot levels of the pyrite shaft. A nominal production of gold was reported from the Blackmon mine, obtained by rocking stream gravels.

Oconee County.—A nominal production of placer gold was reported from the Lay mine, near Walhalla.

Spartanburg County.—The Cowpen branch near Cowpen produced a small amount of placer gold.

York County.—At the Darwin mine, near Smyrna, no production was made in 1915, but it is said that work will be resumed in 1916. The Horn mine was actively worked and was the largest producer in the State. It is said that there are large quantities of ore which can not be shipped to the smelters, but which would pay for milling or smelting if facilities were at hand. The Cathryn (old Martin) mine was operated for a short while in the spring of 1915 and made a small production from a trial shipment of crude ore. It is reported that the property has been closed on account of lack of funds to operate, notwithstanding the fact that there is a considerable quantity of workable ore.

TENNESSEE.

The mine production of precious metals in Tennessee in 1915 was 331.95 ounces of gold and 100,543 ounces of silver, having a combined value of $57,837, all of which was derived from the copper ores of Polk County. No gold or silver ores were treated in the State, nor were the placer deposits of Monroe County operated. There were 623,534 tons of copper ore treated in Polk County, from which 18,046,010 pounds of copper were produced. For the first time in several years Tennessee produced a small quantity of lead, which was obtained from Bradley County. The production of zinc in 1915 was 12,072,902 pounds more than in 1914 and amounted to 32,922,902 pounds.

This remarkable increase is due in great part to the increased operations of the old companies. The new operators produced a relatively small proportion of the total. The average zinc content of ore smelted direct during 1915 was 44 per cent. The crude ore averaged 8 per cent zinc and the concentrates averaged 35 per cent zinc. As will be seen from the table below, the great increase in total value of metals is due more to the increased quantity and value of the zinc mined than to any of the other metals produced; in fact, there was a decreased production of both silver and copper from the Ducktown district.

Mine production of gold, silver, copper, lead, and zinc in Tennessee, 1914–1915.

Year.	Number of mines.		Ore sold or treated.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Copper.	Lead and zinc.							
			Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	2	4	1,011,058	$6,194	97,402	18,737,656	.....	20,850,000	$3,615,516
1915	2	7	1,149,364	6,862	100,543	18,046,010	1,660	32,922,902	7,298,406
Increase or decrease in 1915	.....	+3	+138,306	+668	+3,141	−691,646	+1,660	+12,072,902	+3,682,890

Bradley County.—On the Chatata property, near Charlestown, development has been under way during 1915 on a lead-zinc property carrying sulphide ore. A test lot of galena was shipped, but none of the zinc ore was marketed. The mineralized belt is said to extend about 12 miles from a point near Riceville to Blue Springs.

Green County.—Considerable prospecting for zinc ore was done in the vicinity of Greenville on several properties, but no production was reported during the year.

Hancock County.—Late in 1915 it was reported that Philadelphia interests headed by S. T. Wetherell had acquired a large acreage northeast of the Mascot zinc belt, and it is understood that extensive drilling operations are now in progress. If prospecting warrants development, a railroad connection will be built and a large concentrating plant erected.

Jefferson County.—Near New Market the Loy and Carbonate properties were worked and produced a considerable quantity of zinc ore.

Knox County.—The American Zinc Co. of Tennessee operated the Mascot and Roseberry mines near Mascot with considerable success. This company now has two concentrating mills, one of 2,000 tons capacity and the other 500 tons, the latter a new mill known as No. 3.

Polk County.—The mines of both the Tennessee Copper Co. and the Ducktown Sulphur, Copper & Iron Co. (Ltd.), were in active operation during the year.

Union County.—It is reported that prospecting on the Tennessee-Oklahoma Oil Co.'s land near La Follette has disclosed a considerable quantity of zinc ore. The New Prospect mine, in the Lead Mine Bend district near Sharps Chapel, opened by a 600-foot incline, produced zinc carbonate and sulphide ore saved during development

work. It is reported that the old mill will be rebuilt and will use the flotation process.

Washington County.—The Embreeville mines were actively developed during the year and produced a large quantity of oxidized zinc ore, part of which was shipped crude and part was concentrated by washing and magnetic separation. The properties of the Tennessee Zinc Co., adjoining the Embree mine, were under development and produced some zinc ore, which was shipped without treatment. It is understood that sulphides have been discovered and that with more economic mining and efficient milling of the ores an increased production should result.

VERMONT.

The Pike Hill mines, Orange County, were reopened in December, 1915, and produced some ore carrying copper and silver. Part of this ore was smelted direct and part was concentrated on magnetic separators. It is reported that flotation is being experimented with but the result is not known.

VIRGINIA.

The Virginia production of gold, copper, lead, and zinc in 1915 was valued at $351,403, distributed as follows: Gold, 25.83 ounces, valued at $534; copper, 27,744 pounds, valued at $4,855; lead, 678,741 pounds, valued at $31,901; zinc, 2,533,173 pounds, valued at $314,113. The decrease in the production of copper is due in part to the fact that some of the pyrite mines whose ores contain a little copper did not report any production. The lead and zinc mines in Wythe and Pulaski counties were extensively developed and account for the great increase in the production of those metals.

Mine production of gold, copper, lead, and zinc in Virginia in 1914–15.

Year.	Number of mines.			Ore sold or treated.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Gold.	Copper.[a]	Lead and zinc.							
				Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	.....	2	1	15,444	$429	1,458	139,008	254,000	348,000	$47,377
1915	2	4	4	22,759	534	.....	27,744	678,741	2,533,173	351,403
Increase or decrease in 1915	+2	+2	+3	+7,315	+105	−1,458	−111,264	+424,741	+2,185,173	+304,026

[a] Includes pyrite mines which produce copper.

Buckingham County.—The Cowan or Lightfoot mine, near Arvonia, shipped some ore containing copper and gold during 1915, and it is reported that the Albemarle or Faber property is being reopened and will have a new mill for the treatment of the mixed lead-zinc sulphide ore. There has been some interest shown in other parts of the county.

Charlotte County.—Prospecting near Keysville during the latter part of 1915 resulted in the opening of some copper ores, none of

which were reported shipped during 1915, though it is known that some ore was shipped early in 1916.

Fairfax County.—At the Howard copper mine, near Herndon, some prospecting was done, which resulted in a small shipment of copper ore and slag carrying gold. It is reported that results did not warrant continuation of this work.

Fauquier County.—There was some prospecting in the county during the year, but no metals were produced.

Fluvanna County.—Some interest was shown in prospecting copper-gold deposits, and a small output of gold was reported from mines near Kents Store.

Goochland County.—In Goochland County there was a little prospecting at various properties and the old Gilmer mine was operated for four months, producing some gold and silver by amalgamation.

Halifax County.—There was little production in the Virgilina district during 1915. The Seaboard Copper mine has been reopened and the mill equipped to handle 100 tons a day. Trial shipments of concentrates are stated to indicate a satisfactory recovery and it is said the property will be actively worked during 1916. It is also reported that the High Hill, Copper King, and Durgy mines—the last two in Granville County, N. C.—will be reopened.

Louisa County.—The Allah Cooper mines were operated largely for the sulphur content of the pyritic ore, but some lead and zinc were recovered as a by-product. Cement copper was also recovered by the Sulphur Mining & Railroad Co. from mine waters.

Pulaski County.—Zinc ore was mined from the Clark ore bank near Allisonia, and it is reported that several other properties in the vicinity are receiving attention.

Scott County.—Prospecting has been active along the Tennessee State line in the vicinity of Arcadia, Tenn., and it is reported that the Southern Zinc & Mining Co. will begin operations on the Hickman tract early in 1916.

Shenandoah County.—Lead and zinc prospects are reported in the vicinity of Moores Store, but no production is reported.

Spotsylvania County.—It is reported that prospecting on the Holladay property has developed a considerable quantity of lead-zinc sulphide ore, which is being opened by the Virginia Lead & Zinc Corporation, according to latest reports. This discovery has resulted in the activity on several other properties.

Wythe County.—The zinc belt in Wythe County, near Austinville and Ivanhoe, was under extensive development during 1915, and several mines shipped zinc ore. No ore was raised at the Bertha mine by the Bertha Mineral Co., though the treatment of tailings resulted in some output of zinc. The Ivanhoe Furnace Co. built a concentrating mill and produced considerable zinc ore and concentrates. The Austinville mine of the Bertha Mineral Co. was in continuous operation during the year.

SECONDARY METALS.

By J. P. Dunlop.

INTRODUCTION.

"Secondary metals" are those recovered from scrap metal, sweepings, skimmings, and drosses, and are so called to distinguish them from the metals derived from ore, which are termed "primary metals." The distinction does not imply that secondary metals are of inferior quality, for metals derived both from ore and from waste material vary in purity and in adaptability for use in making certain products. The reports to the United States Geological Survey now include the secondary recoveries of copper, zinc, lead, tin, antimony, and aluminum, and in 1916 the inquiry will probably be extended to include nickel. The figures obtained by the Survey are given as a supplement to the regular reports on primary metals in order to enable producers and consumers to form a more comprehensive idea of the quantities of metal available for consumption; in fact, they constitute an essential addition to the six general reports on primary metals, though only a part of the recovery of waste metals is given. That the value of the secondary recoveries from six metals amounted to more than $114,000,000 in 1915, and that this value is exclusive of the value of old iron, steel, platinum, nickel, gold, silver, and other metals, must impress any investigator with the importance and vast extent of the trade in waste metals.

It was known to the metal interests that considerable and increasing quantities of scrap metal were available for consumption, but it is doubtful whether even those handling metals had any adequate conception of the quantity of this secondary material. The general public, and even those actively engaged in metal mining, do not yet fully appreciate either the quantity or the value of waste materials, of which metals are only a part. That the value of such materials collected, treated, and reused every year amounts to several hundred million dollars, and that many large and ever-expanding industries are entirely or partly dependent upon waste or junk has been more emphatically brought to public attention during the last year than at any other period. The advice and admonition given by the press, notwithstanding the fact that in many cases overstatements were made regarding the market price paid by dealers for various kinds of waste, was applicable to the American people. Efficient and prosperous individuals and large corporations have long realized that the saving in small things was essential and necessary, but the ordinary well-to-do class of people and smaller manufacturing and business interests have been too prone to confuse saving and careful

conservation of waste material with penuriousness. More careful organization in the purchase of such material and more extensive segregation of the various classes of such material on the part of the millions accumulating and at present destroying it would be a notable advance in conservation.

The high prevailing prices for nearly all metals and the scarcity at times of spot metals in 1915 had the effect of making users of metal increase their efforts to save scrap and other waste. It is reasonable to assume that, with copper worth double, zinc worth three times, and antimony worth eight times the normal values, more care was taken to save and properly segregate the metals. The employment of chemists by large manufacturers is not unusual, and general and satisfactory use of scrap metals has been brought about by more careful attention to details in assaying and in smelting practice. The economic sin of using a high-priced metal or alloy when a lower priced one gives equally satisfactory service is much more rare than formerly. Moreover, there are now many careful and responsible dealers in and refiners of scrap metals, many plants treating secondary material only, which compare favorably in size and quality of production with smelters treating ores, and the general plane of business integrity of the small dealers is on the whole as high as in other branches of trade.

It is not the large manufacturer but the individual housekeeper and the small tradesman who are responsible for the opinion that the inhabitants of the United States are the most wasteful in the world. Paper, twine, rags, rubber, and other so-called refuse are burned or are indiscriminately mixed and dumped out so that their recovery is rendered more difficult and their value is depreciated. To give one instance of metal waste which appears small and unimportant: Tin, lead, and aluminum foil are discarded every day in nearly every household and store. Probably not one-tenth of the tin or other foil made is ever reused, though such foil can be made only from the purest metal.

In 1915 dealers in and smelters and refiners of waste metals experienced the greatest period of prosperity ever known. Metal stocks at the beginning of the year were fairly large and the continued advance in the value of nearly all metals as well as the active demand for spot metals made business unusually profitable. Generally waste metals are purchased at prices which enable the dealers or smelters to sell them at a price sufficiently lower than that quoted for virgin metal to attract buyers. Some virgin metals, as spelter, aluminum, and antimony, were frequently difficult to purchase in small lots for immediate delivery, and as long-time selling contracts are not usual in the secondary metal trade, it is probable that the average spot selling price of secondary spelter in 1915 exceeded the average sales price (0.124 cent) reported by regular zinc smelters.

The production of spelter from drosses and skimmings made by these zinc smelters, which do not treat any ore, was only about 900 tons larger in 1915 than in 1914, although one new smelter was in operation. This small increase was probably due to the fact that considerable spelter was redistilled. Such a procedure was profitable on account of the very high prices of spelter suitable for brass used for ammunition.

Two smelters in New Jersey and one each in New York and Pennsylvania, which treat only drosses and skimmings, use large graphite retorts of 600 to 800 pounds capacity instead of the small clay retorts used by smelters treating ore or mixed ore and drosses. The many uses of zinc drosses and skimmings create active competition for their purchase. Considerable zinc is recovered by sweating, and the residues are then sold for redistillation. The secondary spelter varies in quality just as the spelter derived from ore does, but a large proportion of the secondary spelter is reported to be of excellent quality.

The quantity of secondary remelted brass used in 1915 was much greater than in 1914, and a much larger proportion was clean new scrap, although careful attention was given to the recovery of old used brass and copper from every possible source.

The increased recoveries of secondary tin, lead, and aluminum were those normally to be expected with much-improved business conditions. The high prices of metals made it necessary or advisable for many consumers, who formerly had always used virgin metals, to purchase scrap material. As shown in an editorial in Metal Industry of December 15, 1915, the improper and careless use of scrap metal frequently resulted in faulty products. The precautions necessary in the selection and use of secondary metals are set forth in the editorial.

The railways hauled more freight and had fewer idle cars, and they reported a considerable increase in the quantity of babbit, bearing metals, and brass reused.

The following article, "Growing value of the nonferrous scrap pile,"[1] shows the methods and extent of the recovery and reuse of metals by railways:

> The modern brass foundry has always been considered a fertile field for the development of systematized reclamation of waste materials, but it has required a phenomenal rise in the price of nonferrous scrap to bring home to many manufacturers the real importance of saving every particle of metal that can be recovered economically. An example of the extent to which scrap may be utilized or turned to good account is furnished by the practice in vogue at the brass foundry of the Pennsylvania Railroad at Altoona, Pa.
>
> This foundry makes a large percentage of the brass castings used on locomotives and cars on the Pennsylvania lines east of Pittsburgh. The output, which amounts to about 35 tons every 24 hours, consists of journal bearings, metallic piston rod and valve stem packing, valves, cocks, driving box shoes and wedges, and miscellaneous locomotive and car castings of brass and aluminum.
>
> The organization of the maintenance of equipment department of the railroad is such that the scrap metals which accumulate at all points where cars and locomotives are repaired may be collected at the principal shops on the various divisions, and from there shipped to the foundries of the company at Altoona and Renovo, Pa. At these points, and especially at Altoona, methods have been developed to reclaim a large amount of the scrap materials received from the outlying shops. A small percentage has to be sold because the company has no way of economically recovering the metal.
>
> Of first importance in the value of scrap is the class of material known as journal bearings. A few years ago these bearings constituted 50 per cent of the output of the foundry, but at the present time they amount to only 30 or 40 per cent of the total. The bearings are made of bronze and are lined with a soft metal. The linings are melted out of the bronze bodies and cast into ingots which are remelted to refill bearings in which the linings have worn below the standard limit of wear. The system for recovering this material

[1] The Foundry, June, 1916, pp. 227–228.

is so complete that only 25 per cent of new metal is used in the ordinary manufacture of journal bearings. * * *

Another source of recovered brass is the discarded and broken valves, spindles, cut-out cocks, nipples, brasses, etc., which accumulate in engine houses and machine shops. Material of this kind is shipped to the foundries, where an inspector goes over it to separate the iron and other foreign metals. Many of the more complex articles, apparently brass from the appearance of the exterior, have iron or steel sleeves or spindles inside. The inspector carries a small portable electric magnet, which instantly detects the presence of the undesirable metals, and the article is set aside to be broken up so that the brass may be separated from the iron or steel. The clean brass obtained in this manner is melted and goes back into the manufacture of castings.

Phosphorus and plastic bronze turnings from the various machine shops furnish a considerable amount of scrap. * * * In most cases material of this kind is comparatively free from dirt, as the machine shop workmen are instructed to use different receptacles under their machines to catch the chips from each kind of metal. Unless the bronze is badly mixed with nonmetallic materials, it is fed to a magnetic separator, which picks out the iron and steel particles. Analysis of the metal as it comes from this machine shows that the bronze is extremely free from foreign substances. It is melted and used again in the making of bronze castings. Over 75,000 pounds of turnings of this kind are recovered from the magnetic separator each month at Altoona.

The manufacture of soft metal for piston and valve stem packing is an important part of the work of the Altoona foundry, since the packing for practically every Pennsylvania locomotive east of Pittsburgh is made there. On account of the necessity of maintaining a constant quality of metal, samples of the ingots are carefully analyzed before the metal is poured into the form of packing. This procedure simplifies the use of scrap metal considerably, for it enables the testing laboratory to prepare a formula to bring the resultant metal up to standard.

The packing metal, discarded when shopmen renew the packing, is sent to the storehouse, where it accumulates and is later sent to the foundry. Here it is melted and cast in pigs. About 4,000 pounds are melted at one heat. The pigs of each heat are carefully labeled, and samples are sent to the laboratory. A record of the analysis is kept, and a formula showing the ingredients which must be added to the scrap to bring the resultant metal up to the specifications of standard packing metal is prepared. The pigs are melted again and new materials added according to the formula. If the resultant mixture is satisfactory, as shown by a final analysis, the metal is ready to be cast into packing. The average quality and quantity of the metal reclaimed is such that the formulas provide for about 50 per cent of scrap and a like amount of new metal.

The sweepings from the foundry floor contribute about 7,000 pounds of clean brass each month. The material is wheeled from the floor of the foundry to a ball mill, which crushes the material and washes the mud from the metal. After it has been reduced to a comparatively clean mixture of various metals, it is fed through the magnetic separator. The analyses of the brass as it leaves this machine show that not only the iron and other magnetically affected metals, but also the antimony has been removed. * * *

Crucibles from the foundry are usually sold to smelters. Very little attempt has been made to reclaim the brass from the crucibles at Altoona. The broken pots * * * are held until 10 or 15 tons have accumulated and then they are sold. From $5 to $6 per ton is paid for this kind of scrap.

The recovery of nonferrous metals, however, is not confined to the recovery of cast brass parts. Copper wire is utilized by burning the insulation, cleaning the ash, cutting the wire into convenient bundles, melting it, and casting in small pigs. Car seals are heated to recover the lead. Batteries are saved and the lead, zinc, and the mud recovered. Another source of lead is the obsolete and condemned driving-wheel centers from locomotives. Large passenger locomotive wheels contain about 500 pounds of lead to counterbalance the throw of the rods and crank pins. This metal is recovered by heating the center and pouring the molten lead into pigs of convenient size. The wheels are stripped of their lead content at a cost of about $0.40 each.

The price of scrap and the cost of reclaiming it are the two factors governing the extent to which recovery of metals may be carried with economy. Until the recent high prices of nonferrous metals and alloys, it was questionable whether the extensive efforts to reclaim brass from sweepings and from other

small sources was a paying procedure in many shops. In too many cases the cost of labor more than offset the value of the materials saved. Existing conditions in the old-metal market have changed this, and at the present time, perhaps as never before, there is good reason for waging war against the waste of scrap material with unusual thoroughness.

Copies of this report for the year 1914 (which are still available for distribution) contained excerpts relating to the segregation of scrap metals taken from "Metal Industry" and also the standard classification for old metals adopted by the metal section of the National Association of Waste Material Dealers.

It is impracticable and unnecessary to segregate the statistics relating to the refining, remelting, and reusing of secondary metals according to States, but more than 90 per cent of the refining and smelting of drosses and scrap metals in the United States is confined to the territory east of St. Louis and north of the Ohio River.

About 55 per cent of the secondary aluminum was reported from the States of Ohio and Michigan, 25 per cent from Illinois and Wisconsin, and 17 per cent from New York, New Jersey, and Massachusetts.

Smelters and refineries in St. Louis and Chicago recovered about 41 per cent of the antimony in alloys, and those in New York and Philadelphia about 28 per cent. The largest recoveries from tin dross, tin scruff, and clean tin scrap were made in Pennsylvania, New York, and New Jersey. The recoveries of lead, zinc, brass, and copper, and of such alloys as babbitt, bronze, and pewter, were more generally distributed. The greatest number of the larger smelters or refiners of secondary metals are located at or near New York, Philadelphia, Chicago, Pittsburgh, St. Louis, Detroit, Cincinnati, Cleveland, and Tottenville, N. Y., though there are many large and small plants at other places.

The value of the secondary metals exclusive of gold, silver, platinum, iron, steel, and ferro-alloys recovered in the United States in 1915 was $114,304,930, compared with $57,039,706 in 1914. The increase was partly due to larger use and partly to much higher average prices.

SECONDARY COPPER.

The total quantity of secondary copper recovered in 1915, on the assumption that the brass remelted had an average copper content of 70 per cent, was 196,187 tons, of which 29,787 tons (13,900 tons more than in 1914) was recovered by plants refining primary metals and the remainder by plants treating only secondary materials. The copper produced by smelters of the latter class includes 54,150 tons of pig copper, 16,000 tons of copper in alloys other than brass, and 96,250 tons of copper in remelted brass. These figures indicate an increase for 1915 of about 17,500 tons of pig copper, 26,900 tons of copper in brass, and about 10,000 tons in alloys other than brass. At least 75,000 tons was recovered from clean scrap made in the course of manufacture of copper and brass ware, so that less than 121,000 tons was obtained from ashes, cinders, and scrap, or from material that had actually been used and discarded.

From the reports received it is quite evident that there was a large increase in the quantity of old scrap brass and copper smelted and that there was an even larger proportionate increase in the quantity of clean new scrap remelted.

The value of the copper, both as metal and in alloys, is computed at the average yearly price quoted for casting copper by the American Metal Market.

According to the Bureau of Foreign and Domestic Commerce, the exports for the calendar year 1915 of scrap brass, fit only for remanufacture, were 6,396 tons and the imports of copper and brass scrap were 12,064 tons. Many railways sell or turn in the larger portion of their brass and copper scrap and other metal waste to dealers in part payment for new material, but the reports received show that the railways utilized in their own shops and foundries more than 13,000 tons of brass, in addition to 850 tons of copper and 4,750 tons of copper in alloys other than brass.

The production of copper from secondary sources in 1915 was equal to about 24 per cent of the refinery output of primary copper in the United States from all sources, or about 28 per cent of the primary copper smelted from domestic ore.

SECONDARY LEAD.

The secondary lead recovered in 1915 amounted to 78,900 tons, or about 17,800 tons more than in 1914. The secondary lead recovered as pig lead increased about 7,000 tons, though the recovery of secondary pig lead made by those smelters whose product is mainly primary metals was about 2,000 tons less in 1915 than it was in 1914. The recovery of lead in alloys increased more than 10,700 tons, compared with 1914. This increase in both pig lead and lead in alloys was undoubtedly due to the expansion in railroad traffic and manufacturing. A large portion of the recovered lead in alloys was derived from old babbitt, solder, type metals, and white metal drosses. The main sources of secondary pig lead are old pipe, lead cable, battery lead, and lead lining of acid tanks. Regular smelters reported the recovery of 10,403 tons of lead from scrap lead and scrap antimonial lead.

The quantity of scrap antimonial lead remelted by regular smelters was nearly double that reported in 1914.

The total output of secondary lead was equal to 14.3 per cent of the refined primary lead produced in the United States in 1915, compared with 11.3 per cent in 1914. It was exceeded by the primary domestic lead output of only three States, Missouri, Idaho, and Utah, and was more than the combined quantity of primary lead derived from the ores smelted from all other States.

SECONDARY ZINC.

The output of secondary zinc (including that in brass) amounted to 92,575 tons and equaled 19 per cent of the production of primary spelter in the United States in 1915, compared with 20 per cent in 1914. The recovery was about 21,000 tons more than in 1914, of which increase more than 9,200 tons was the gain in redistilled spelter from drosses and skimmings. The zinc recovered in alloys other than brass amounted to 5,300 tons, compared with 3,914 tons in 1914. Of the 52,900 tons of secondary zinc recovered as spelter, 29,764 tons were obtained by redistillation from drosses and skimmings. Of this quantity 14,868 tons were obtained by smelters whose principal source of zinc is ore. This was about 8,200 tons more

than the recovery from drosses and skimmings in 1914. In addition to the 52,900 tons of remelted and redistilled spelter, it is estimated that at least 4,000 tons of zinc chloride was made and likewise about 46,494 tons of the zinc pigment lithopone (containing approximately 32 per cent zinc sulphide and oxide). The zinc used in both of the last-named products is derived almost altogether from zinc drosses and skimmings. The exports of zinc drosses, which amounted to 2,526 tons in 1914, increased to 3,668 tons in 1915.

SECONDARY ANTIMONY.

The production of secondary antimony, of which all but 2 tons was recovered in alloys, increased from 2,646 short tons in 1914 to 3,102 tons in 1915. The value given is arbitrary and is based on the average yearly price for ordinary brands of antimony published by the American Metal Market. The regular smelters reported the recovery of 376 tons of antimony contained in antimonial lead scrap, an increase of 232 tons. The principal materials refined or remelted which contained antimony as an alloy were hard lead drosses, babbitt, solder, pewter, and type metal. The imports in 1915 of antimony as metal in ore or as oxide or salts amounted to 9,322 tons, and the recovery from secondary sources was equal to 33 per cent of the imports.

SECONDARY TIN.

Apparently there were no domestic tin ores smelted in the United States in 1915, though some tin concentrates were shipped from Nome, Alaska, to Singapore, Federated Malay States, for treatment, and there was considerable agitation for the domestic smelting of both Alaskan and Bolivian tin ores. A new tin smelter was constructed by the American Smelting & Refining Co., at Perth Amboy, N. J., and tin concentrates from Bolivia were imported, but the plant was not operated until the spring of 1916. This condition makes secondary tin an important factor in supplying domestic consumption. The secondary tin recovered in 1915 was equal to about 24 per cent of the tin imported, as metal or as oxide, into the United States during the year (57,820 short tons). Secondary tin recoveries increased from 12,447 tons, valued at $8,887,158, in 1914 to 13,650 tons, valued at $10,554,180, in 1915. The quantity recovered as tin was 5,250 tons and that in alloys and chemical compounds 8,400 tons. The value of the recovered tin here given is arbitrary and is based on the yearly average price for new metal given by the American Metal Market. The secondary tin in alloys increased about 500 tons and the secondary pig tin about 700 tons. The secondary pig tin was less in quantity than in 1913, for in both 1914 and 1915 a large quantity of tin chloride and tin oxide was made from clean scrap tin plate.

The recovered tin in alloys includes the tin content of products made in several plants from clean tin plate scrap. This included some tin oxide, putty powder, etc., but consisted mainly of tin chloride. The production of these compounds is calculated as metal and not separately stated in order to avoid disclosing confidential information. As the products are made from scrap tin and thus conserve the primary metal, they are properly regarded as recovered tin.

The largest recoveries of tin were made from the scruff and drosses that occur in making tin and terneplate and amounted to over 3,800 tons.

About 2,700 tons of tin were recovered from clean scrap tin plate either as pig tin or as tin chloride or tin oxide. Apparently only about 550 tons of pig tin were recovered from scrap tin (not tinplate) clippings, old tin pipe, and tin foil, and it is impossible to give the separate quantities of tin recovered from these sources.

Only one plant reported using old tin containers, from which the tin coating and solder were first sweated and the black plate was then remelted to make sash weights. Tin scrap and old tin cans are used in the western mining regions for their iron content for the precipitation of copper from mine waters. The thin coating of tin, the undesirability of the black plate base for reuse, and the cost of labor in collecting, shipping, and cleaning old food containers prevent the profitable treatment of such material.

An increased quantity of tin was recovered in bronze, and a considerable part of the brass remelted contains a small quantity of tin and of lead. Other alloys from which secondary tin was recovered were solder, babbitt, pewter, terne metal, and electrotype metal.

SECONDARY ALUMINUM.

The recovery of secondary aluminum as pig aluminum or in alloys in 1915 amounted to 8,500 tons, valued at $5,802,100, as compared with 4,522 tons, valued at $1,673,140, in 1914. The quantity recovered in alloys amounted to 2,800 tons, nearly all of which was an alloy of 92 per cent aluminum and 8 per cent copper. Most of the secondary aluminum was recovered from clean clippings and borings and was probably all used in making castings.

The increase in quantity of secondary aluminum in 1915 was due to the material increase of old castings used in automobiles. The high prices prevailing most of the year no doubt resulted in considerable aluminum wire being remelted.

Secondary metals recovered in the United States in 1914 and 1915.

Metal.	1914		1915	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Secondary copper, including that in alloys other than brass	58,556	$15,435,362	99,937	$33,498,882
Remelted brass	99,038	21,054,300	137,500	40,788,000
Secondary lead	29,337	4,762,836	36,400	7,416,600
Recovered lead in alloys	31,725		42,500	
Secondary spelter	42,969	4,782,066	52,900	14,433,600
Recovered zinc in alloys other than brass	3,914		5,300	
Secondary tin	4,535	8,887,158	5,250	10,554,180
Recovered tin in alloys	7,912		8,400	
Secondary antimony	1	444,844	2	1,811,568
Recovered antimony in alloys	2,645		3,100	
Secondary aluminum	2,791	1,673,140	5,700	5,802,100
Recovered aluminum in alloys	1,731		2,800	
	.....	57,039,706	.....	114,304,930

MANGANESE AND MANGANIFEROUS ORES.

By D. F. Hewett.

INTRODUCTION.

The year 1915 was eventful in the manganese industry of the United States. There has been great increase in the production of each variety of ores, although the total quantity is still far below the country's need. New deposits that may become important sources of production have been explored in several States and old mines have been reopened. In the manganese alloy industry several new producers of ferromanganese have entered the field and several companies that have not attempted to make alloys for some years have again become producers.

These activities were directly due to the stimulus of the high prices that were offered for ores and alloys, which in turn were caused by the elimination of established sources of ore in Russia and India and of the alloys usually imported from England and Germany. Inasmuch as prices of ores and alloys in the United States depend almost wholly on the foreign supplies, it may serve a purpose to inquire at this time concerning the effect upon the prices of these materials of the conclusion of peace in Europe. It will be recalled that since the temporary business disturbance in this country caused by the declaration of war prices of both ores and alloys have risen steadily but rather slowly considering the certainty of serious shortage in supplies.[1] It seems highly probable that prices will drop appreciably whenever it is realized that peace is about to be declared, and then the decline will be more slow and regular until normal prices are reached, but these will scarcely be attained within a year after the conclusion of peace.

Prudent observers will realize that the advantage given to domestic producers is temporary; but the country, as well as individuals who are directly interested, may permanently profit by the temporary advantage if the new deposits prove to be capable of producing ore in competition with foreign deposits. It is to be hoped also that the special abilities as well as equipment that have been developed by the new producers of alloys may enable them to supply continuously a larger part of the alloys that are needed by the industries.

On the assumption that other factors do not interfere, it is probably true that the industries of any nation are most stable when it contains within its borders the basic raw materials essential to its industries,

[1] The rise in prices of ores and alloys between Jan. 1 and May 1, 1916, has been much greater than during the preceding 16 months. On May 1 the price for 50 per cent manganese ore is quoted at $30 to $32 a ton and for 80 per cent ferromanganese at $175 to $200 a ton for future delivery. For the immediate delivery of a small lot $400 a ton was paid.

but it is apparent that modern industries in many larger nations demand a diversity of raw materials rarely available on one continent. The cheap water transportation of modern times permits the competition not only of foreign with domestic resources, but of several foreign resources for a given market, and in the absence of tariffs there is a tendency for the richest resources to supply the markets of the world and to determine prices.

In the case of manganese ore, which has become so necessary to modern industries and which for a period of years was supplied by many deposits in several countries, there has been a steady decline in production from minor deposits relatively near markets and a corresponding increase in production from a few rich, even though remote deposits. None of the industrially important nations produce more than a very small part of the manganese ore that they need; all of them have procured most of it in normal times from the three important sources in the world, Russia, India, and Brazil. Many countries, such as Chile, Turkey, and Spain, which once supplied large quantities of manganese ore, have been unable to compete with the richer and more extensive deposits of Russia, India, and Brazil, and their production has steadily declined in recent years.

The domestic production of manganese ore during 1915 was 9,709 long tons, about four times the production for 1914 and the greatest output since 1901. The production came from Georgia, California, Virginia, Arkansas, Arizona, Alabama, Colorado, Tennessee, and Texas, in the order named. Of this quantity 9,159 tons was used in the manufacture of ferromanganese and 550 tons, from deposits in Arizona, California, Colorado, Utah, and Virginia, was of higher grade and was used for special purposes, such as making dry batteries and flint glass.

The production of manganiferous iron ores was 801,290 tons, most of which came from established sources. Of this quantity, 69,416 tons contained more than 15 per cent manganese and most of this was used in the manufacture of low-grade ferromanganese, whereas those ores which contained less than 15 per cent manganese were used largely in making high manganese pig iron.

The only information available concerning new deposits has been received from owners of property. All the deposits except those in two localities, Grand County, Utah, and San Miguel County, Colo., appear to yield ore which contains more than 1 per cent iron and is therefore only available for the manufacture of ferromanganese. The ore from the deposits in the two localities in Utah and Colorado is low in iron and copper, and has been shipped to makers of dry batteries and flint glass. The ores of this grade produced in 1915, however, have supplied only an insignificent part of the demand, and the situation in the dry-battery industry is reported to be serious. The stocks of Russian ores held by brokers and consumers at the outbreak of the European war are nearly exhausted (May, 1916), and one important manufacturer has been forced to suspend operations.

A surprising feature of the manganese-ore industry during the year was the great increase in imports from Brazil, which were more than twice those of 1914 and more than four times the average of the preceding 14 years. This increase more than made up for the decreased imports from India and the complete cessation of imports from

Russia. The imports from Cuba were received from four mines, and there is prospect of greater production for 1916.

The decrease in imports of ferromanganese for 1915 was due in part to the British embargo on shipments which extended from November, 1914, to March, 1915, and in part to the decrease in available supply abroad. The price for ferromanganese for prompt delivery advanced from $80 a ton in January to $115 in December.

The following table shows the relation of the production and imports of manganese ores and alloys to the production of steel in the United States. It will be observed that the imports of ore and recently of ferromanganese, rather than the domestic production, respond to the fluctuations in production of steel.

Manganese alloys and ore produced in the United States and imported from important foreign sources, 1890–1915, in long tons.

Year.	Steel.	Ferromanganese.		Spiegeleisen.		Manganese ore.				
	Production.	Production.	Imports.	Production.	Imports.	Production.	Total imports.	Imports from—		
								Russia.	India.	Brazil.
1890.....	4,277,071	.....	.....	.....	.....	19,287	34,154	.....	.....	.....
1891.....	3,904,240	.....	.....	.....	.....	22,452	28,825	.....	.....	.....
1892.....	4,927,581	.....	.....	.....	.....	13,613	58,572	.....	.....	.....
1893.....	4,019,995	.....	.....	.....	.....	7,718	68,113	[a] 36,070	[b]	.....
1894.....	4,412,032	.....	.....	.....	.....	6,308	44,655	[a] 28,300	.....	[c]
1895.....	6,114,834	.....	.....	.....	.....	9,547	86,111	[a] 55,987	.....	.....
1896.....	5,281,689	.....	.....	.....	.....	10,088	31,489	[a] 3,600	.....	.....
1897.....	7,156,957	.....	.....	.....	.....	11,108	119,961	38,910	17,400	12,083
1898.....	8,932,857	.....	.....	.....	.....	15,957	114,885	46,396	5,944	17,031
1899.....	10,639,857	.....	.....	.....	.....	9,935	188,349	73,397	17,950	28,115
1900.....	10,188,329	[d]	[e]	[d]	[e]	11,771	256,252	132,121	10,650	54,451
1901.....	13,473,595	59,639	20,750	231,822	26,827	11,995	165,722	32,600	11,000	48,029
1902.....	14,947,250	44,526	50,388	138,408	68,813	7,477	235,576	3,338	64,170	102,550
1903.....	14,534,978	35,961	41,519	156,700	122,015	2,825	146,056	5,576	35,960	76,910
1904.....	13,859,887	57,076	21,813	162,370	4,623	3,146	108,519	11,959	10,200	66,875
1905.....	20,023,947	62,186	52,841	227,797	55,457	4,118	257,033	24,650	101,030	114,670
1906.....	23,398,136	55,520	84,359	244,980	103,268	6,921	221,260	13,805	154,180	30,260
1907.....	23,362,594	55,918	87,400	283,430	48,994	5,604	209,021	1,000	95,300	52,922
1908.....	14,023,247	40,642	44,624	111,376	4,579	6,144	178,203	250	143,813	17,150
1909.....	23,955,021	82,209	88,934	142,831	16,921	1,544	212,765	14,486	145,140	35,600
1910.....	26,094,919	71,376	114,228	153,055	25,383	*f* 2,258	242,348	33,120	140,965	53,750
1911.....	23,676,106	*f* 74,602	80,263	*f*104,013	20,970	*f* 2,457	176,852	19,103	103,580	41,600
1912.....	31,251,303	*f*125,378	99,137	*f*102,561	1,015	*f* 1,664	300,661	83,334	128,645	81,580
1913.....	31,300,874	*f*119,495	128,070	*f*106,980	77	*f* 4,048	345,090	124,337	141,587	70,200
1914.....	23,513,030	*f*100,731	82,997	*f* 76,625	2,870	*f* 2,635	283,294	52,681	103,583	113,924
1915.....	32,151,036	*f*144,260	55,263	*f*114,556	200	*f* 9,709	320,778	.....	36,450	275,579

[a] Drake, Frank, The manganese ore industry of the Caucasus: Am. Inst. Min. Eng. Trans., vol. 28, p. 191, 1898.
[b] First shipment made from India.
[c] First shipments made from Brazil.
[d] Figures for ferromanganese and spiegeleisen combined prior to 1901.
[e] Figures for fiscal years only available prior to 1901.
f Marketed production.

SOURCES OF MANGANESE.

Manganese minerals.—For commercial purposes materials that are sources of manganese are separated into four classes: (1) Manganese ores, (2) manganiferous iron ores, (3) manganiferous silver ores, and (4) manganiferous zinc residuum. This classification is based on the character of the minerals now available in the United States and is due largely to the nature of the deposits, and as it is purely commercial it may be incomplete if applied to resources in foreign countries, or it may contain superfluous classes. Thus the United States alone possesses large deposits of franklinite, which when roasted

yields manganiferous zinc residuum. Though manganese forms a part of about a hundred minerals and is a relatively widespread element, practically all the manganese of commerce is derived from material containing one or more of the first seven of the minerals named in the following table:

Principal manganese minerals.

Mineral.	Composition.	Percentage of manganese.
Polianite	MnO_2	63.2
Pyrolusite	$MnO_2.nH_2O$	60–63
Psilomelane	$MnO_2.(MnKBa)O.nH_2O$	45–60
Wad	Hydrous impure mixture of manganese oxides	5–50
Manganite	$Mn_2O_3.H_2O$	62.4
Braunite	$3Mn_2O_2.MnO.SiO_2$	69
Franklinite	$(FeZnMn)O.(FeMn)_2O_3$	10–19
Rhodochrosite	$MnO.CO_2$	47.56
Rhodonite (manganese pyroxene)	$MnO.SiO_2$	41.9
Tephroite (manganese olivine)	$2MnO.SiO_2$	54.3
Spessartite (manganese garnet)	$3MnO.Al_2O_3.3SiO_2$	33.3

Manganese ores.—Commercial manganese ores are those which contain at least 35 per cent manganese and otherwise conform to the specifications of the trade in which they are used. About 90 per cent of the manganese ore consumed in the United States is converted into ferromanganese which contains about 80 per cent manganese. The ores best adapted to this use contain more than 40 per cent manganese, and except for the limits—usually specified—of 0.20 per cent phosphorus and 8 per cent silica, no other elements that are commonly present hinder the use of ore for this purpose. In order to be available for use in making dry batteries, however, ore should contain at least 80 per cent manganese dioxide, less than 1 per cent iron, and less than 0.05 per cent of copper, nickel, or cobalt. Ore adapted to use in making flint glass should contain less than 1 per cent iron.

MANGANESE ORE.

PRODUCTION.

The following table shows the quantity, value, and average price per ton of the manganese ore produced and marketed in the several States for 1913, 1914, and 1915:

Manganese ore sold in the United States, 1913–1915.

State.	1913			1914			1915		
	Quantity (long tons).	Value.	Average price per ton.	Quantity (long tons).	Value.	Average price per ton.	Quantity (long tons).	Value.	Average price per ton.
Arkansas							1,343	$13,333	$9.93
California				(a)	(a)	(a)	2,563	29,004	11.32
Georgia							3,168	33,927	10.71
Virginia	[b] 4,048	[b] $40,480	$10.00	1,724	$18,565	$10.77	1,620	17,988	11.10
Other States [c]				911	8,812	9.67	1,015	19,057	18.78
	[b] 4,048	[b] 40,480	10.00	2,635	27,377	10.39	9,709	113,309	11.67

[a] Included in "Other States."
[b] Includes small quantity produced in 1911 and 1912, but not reported for those years.
[c] 1914: California and South Carolina; 1915: Alabama, Arizona, Colorado, Tennessee, Texas, and Utah.

Reports have been received from 118 owners of manganese mines in 19 States. A production is reported by 35 owners: 8 in California, 7 in Virginia, 7 in Arkansas, 4 in Georgia, 2 each in Colorado, Tennessee, and Utah, and 1 each in Alabama, Arizona, and Texas. No ore was shipped, however, from several mines.

Manganese ore produced in the United States, 1838–1915.

	Long tons.		Long tons.		Long tons.
1838–1879	43,860	1892	13,613	1905	4,118
1880	5,761	1893	7,718	1906	6,921
1881	4,895	1894	6,308	1907	5,604
1882	4,532	1895	9,547	1908	6,144
1883	6,155	1896	10,088	1909	1,544
1884	10,180	1897	11,108	1910 [1]	2,258
1885	23,258	1898	15,957	1911 [1]	2,457
1886	30,193	1899	9,935	1912 [1]	1,664
1887	34,524	1900	11,771	1913 [1]	4,048
1888	29,198	1901	11,995	1914 [1]	2,635
1889	24,197	1902	7,477	1915 [1]	9,709
1890	19,287	1903	2,825		
1891	22,452	1904	3,146		427,082

STOCKS.

The following table shows the quantities of mined manganese ore on hand at the mines at the close of 1913, 1914, and 1915:

Manganese ore on hand at the mines Dec. 31, 1913, 1914, and 1915, in long tons.

State.	1913	1914	1915
Arkansas	25	35	20
California	105	475	2,000
Colorado	.....	15	150
New Mexico	.....	40	40
Tennessee	.....	.....	100
Texas	.....	.....	2,950
Utah	.....	.....	1,000
Virginia	1,855	510	120
Washington	.....	.....	56
	1,985	1,075	6,436

IMPORTS.

The following table was compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce:

Manganese ore imported into the United States, 1913–1915.

Country.	1913		1914		1915	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
Brazil	70,200	$445,680	113,924	$736,769	275,579	$2,240,837
Russia	124,337	712,324	52,681	490,331	.....	.....
British India	141,587	710,024	103,583	504,981	36,450	194,626
Cuba	.....	.....	.....	.....	5,141	69,453
France	1,114	12,578	5	1,580	.....	.....
Netherlands	.....	.....	2,505	52,213	50	1,792
Japan	3	78	40	1,320	2,810	106,434
Germany	2,014	103,612	1,713	92,273	258	23,590
United Kingdom	227	12,082	8,321	136,206	49	4,730
Canada	5	631	64	1,357	325	12,989
Belgium	.....	.....	450	5,913	.....	.....
All other countries	5,603	32,671	8	1,177	116	1,529
	345,090	2,029,680	283,294	2,024,120	320,778	2,655,980

[1] Ore marketed.

Manganese ore imported into the United States, 1906–1915.

	Long tons.		Long tons.		Long tons.
1906	221,260	1910	242,348	1914	283,294
1907	209,021	1911	176,852	1915	320,778
1908	178,203	1912	300,661		
1909	212,765	1913	345,090		

PRODUCTION IN PRINCIPAL PRODUCING COUNTRIES.

The following table gives the latest available statistics with regard to American and foreign production of manganese ore.

Whenever possible the figures are taken from the official publication of the country concerned, which is the case with Canada, Belgium, France, German Empire, India, Italy, and Spain; otherwise, Mines and Quarries, London, is used. The Geological Survey receives assistance in its foreign statistics from Mineral Industry, New York.

Manganese ore produced in principal producing countries, 1910–1915, long tons.

Country.	1910	1911	1912	1913	1914	1915
North America:						
Canada	----------	5	67	----------	25	42
Nova Scotia	22	134	208	(a)	(a)	(a)
United States	2,258	2,457	1,664	4,048	2,635	9,709
South America:						
Brazil [b]	249,954	171,172	152,431	180,738	(a)	(a)
Europe:						
Austria	15,447	15,703	12,275	16,280	(a)	(a)
Bosnia and Herzegovina	3,937	3,543	4,577	5,709	4,055	(a)
France	7,874	5,906	5,488	7,610	(a)	(a)
German Empire	79,291	85,921	(c)	(a)	(a)	(a)
Greece	40	721	7,595	----------	----------	(a)
Hungary	13,061	14,523	10,662	18,706	(a)	(a)
Italy	4,134	3,460	2,599	1,596	1,623	(a)
Russia	719,907	d 572,028	d 911,742	1,289,370	(a)	(a)
Spain	8,471	5,519	17,126	21,254	(a)	(a)
Sweden	5,719	5,347	5,082	3,938	(a)	(a)
Turkey	e 12,008	(a)	(a)	(a)	(a)	(a)
United Kingdom	5,467	4,987	4,170	5,393	3,437	(a)
Asia:						
India	800,907	670,290	633,080	815,047	682,898	(a)
Japan	11,121	9,615	11,862	(a)	(a)	(a)
Portuguese India	(f)	(f)	(f)	(a)	(a)	(a)
Africa:						
Cape Colony	(g)	b 116	----------	(a)	(a)	(a)
Natal	51	----------	----------	(a)	(a)	(a)
Oceania:						
Australia	815	1,151	328	27	6	200
New Zealand	5	----------	----------	----------	----------	(a)

a Statistics not yet available.
b Exports.
c Statistics not available for Empire. Prussia produced 91,018 long tons.
d Exported from Batum and Poti.
e Exported from Stratoni.
f Quantity not stated. Exports valued at $18,609 in 1910, $13,266 in 1911, and $779 in 1912.
g Quantity not stated. Exports valued at $7,786.

MANGANIFEROUS ORES.

Manganiferous ores are of two classes—(1) those which contain iron greatly in excess of manganese and which are smelted direct to a manganiferous cast iron containing 1 to 4 per cent manganese, or those in which manganese equals or is in excess of the iron and which, with other iron ores, is smelted to a similar product or low-grade ferromanganese; and (2) those which are used for fluxing, the manganese oxides forming a more fluid slag. Ores of the first class were mined during 1915 in the Lake Superior region, Arkansas, Colorado, Georgia, and Virginia. Those of the second class were mined in the Tombstone district of Arizona, in the Leadville and Red Cliff districts of Colorado,

and in the Pioche district of Nevada. In general, manganiferous ores are used as a flux in those districts where the smelting of iron ores is of less importance than the smelting of those lead and copper ores that contain gold and silver. The smelting of refractory mixtures is aided by the use of ores that contain high percentages of oxides of iron and manganese.

For use as a flux the value of manganiferous iron ore, like that of many ores which contain both precious and base metals, depends on several factors, among the more important of which are: (1) Combined manganese and iron content, (2) content of silica, (3) content of precious metals, (4) the deductions and adjustments of these factors, based on the temporary demands of the smelter that buys such ores. The ores produced in the Leadville district, Colorado, for 1915, range in composition as follows: Manganese, 4 to 31 per cent; iron, 7 to 53 per cent; siliceous material (insoluble), 7 to 30 per cent; silver, 2 to 15 ounces per ton; gold, trace; lead, trace to 4 per cent. The average composition of the entire product is: Manganese, 13.5 per cent; iron, about 43.5 per cent; siliceous material, 11.2 per cent; silver, 5.5 ounces; gold, trace; lead, 1.4 per cent.

For such ores smelters pay at the rate of 15 cents per unit (or per cent) for the excess over 40 per cent of the combined iron and manganese content after deducting the silica or siliceous material, and for silver 95 per cent of the content at New York quotations. The deduction of 40 per cent from the combined iron-manganese content is made in lieu of a charge for smelting. By this method of calculating, the value of the Leadville ores, exclusive of that of the precious metals, ranges from nothing to $2.70 a short ton, and the average price of the total production in 1915 was $1.16 a ton. If the value of the silver content be added to this, the total average price is $4.06 a ton.

Prior to 1912 it was possible to state only the total value of these ores, as but a single figure—the gross value—has been reported by producers. More complete data are now available and the present method of calculation is more closely in accord with that adopted by the Survey.

The high price of manganese alloys has further stimulated exploration for manganiferous iron ores on the Cuyuna iron-ore range of Minnesota, and the production for 1915 was the greatest thus far recorded.

Manganiferous ores used principally for fluxing or other purposes sold by producers in Colorado and Arkansas, 1912–1915.

Year.	State.	Percentage of manganese.	Quantity (long tons).	Value.	Average price per ton.
1912	Arkansas	20	1,332	$2,997	$2.25
	Colorado	6–24	48,618	12,646	*a*.23
1913	Arkansas	16–25	9,650	19,250	1.99
	Colorado	2–37	49,753	5,874	*a*.12
1914	Arkansas	(*b*)	1,970	3,940	2.00
	Colorado	5–37	39,881	13,688	*a*.34
1915	Arkansas	18–25	2,600	8,544	3.29
	Colorado	4.8–30	30,921	61,129	1.98
			184,725	128,068	.69

a For Colorado ores used for flux, price covers excess manganese and iron only and excludes value of precious metals.
b Not stated.

Manganiferous ores produced in the United States, 1906–1915, in long tons.

Year.	Arkansas.	Colorado.[a]	Colorado.[b]	Lake Superior region.	Virginia.	Other States.	Total.
1906	8,900	32,400	(c)	[d]1,000,000	.....	.....	1,041,300
1907	4,133	67,514	32,197	314,316	.....	(N. M.) 7,000	425,160
1908	4,066	15,973	35,581	467,140	274	.....	523,034
1909	3,325	12,905	52,119	775,035	305	.....	843,689
1910	5,030	.....	55,770	558,634	301	.....	619,735
1911	2,177	.....	41,753	477,920	507	.....	522,357
1912	1,332	.....	48,618	816,984	1,567	.....	868,501
1913	9,650	.....	49,753	612,743	.....	.....	672,146
1914	1,970	2,100	37,781	402,754	1,222	.....	445,827
1915	2,600	15,956	14,965	659,025	1,944	[e]106,800	801,290
	43,183	146,848	368,537	6,084,551	6,120	113,800	6,763,039

[a] Manganiferous silver ore used in the manufacture of spiegeleisen and ferromanganese.
[b] Manganiferous silver ore used for flux.
[c] Not recorded.
[d] Estimated.
[e] Arizona, Georgia, and Nevada.

MANGANIFEROUS ZINC RESIDUUM.

Unique deposits of zinc ore containing franklinite, willemite, zincite, calcite, and minor silicate and other minerals occur near Franklin Furnace, N. J. By mechanical and electromagnetic processes of separation three products are obtained from these ores, one containing the greater proportion of the franklinite and the remaining two the other zinc minerals. The franklinite product is first roasted with anthracite to eliminate the zinc, which is recovered as zinc oxide, and the residue, containing 12 per cent manganese and 40 per cent iron, is smelted to spiegeleisen.

The production of manganiferous residuum has been approximately constant since 1911. No price is given for this material as it is not sold in the open market, but is reduced to spiegeleisen by the company that produces it. The production from 1889 to 1915 is given in the following table:

Manganiferous residuum produced from zinc roasting in the United States, 1889–1915.

	Long tons.		Long tons.		Long tons.
1889	43,648	1899	65,010	1909	141,264
1890	48,560	1900	87,110	1910	137,173
1891	38,228	1901	52,311	1911	109,296
1892	31,859	1902	65,246	1912	104,670
1893	37,512	1903	73,264	1913	102,239
1894	26,981	1904	68,189	1914	100,198
1895	43,249	1905	90,289	1915	159,318
1896	44,953	1906	93,461		
1897	33,924	1907	93,413		2,050,092
1898	48,502	1908	110,225		

NOTE.—The manufacture of spiegeleisen from manganiferous residuum was begun in 1870, but there is no record of the tonnage of raw material used prior to 1889.

FERROMANGANESE AND SPIEGELEISEN.

The marketed production of ferromanganese in 1915 was 144,260 tons, or about 45 per cent greater than in 1914, and the largest recorded. This output was derived from nine plants owned by six companies, in comparison with that from five plants owned by three

companies in 1914. The production of spiegeleisen in 1915 was 114,556 tons, or about 50 per cent larger than in 1914. The largest output of spiegeleisen was recorded in 1906, when 244,980 tons were produced.

The year 1915 will probably prove to be eventful in the manganese-alloy industry, as it marks the entrance of several of the important independent steel companies as producers of ferromanganese. For some years two plants of the United States Steel Corporation have made a large part of the domestic ferromanganese, and independent steel makers have depended on the imported article, which has been derived largely from England. None of the important steel-producing countries, England, Germany, France, Belgium, or the United States, appear to possess within their borders adequate supplies of manganese ore, but each, except the United States, makes the needed ferromanganese from imported ore, and the first two nations export large quantities of this product.

Although the scales of wages are said to have given these countries an advantage over the United States, it is possible that the industry may become sufficiently well established during the present crisis to enable domestic producers to supply a larger part of domestic needs.

Ferromanganese and spiegeleisen produced in the United States, 1872–1915.

	Long tons.		Long tons.		Long tons.
1872	4,072	1888	48,901	1903	192,661
1873	3,930	1889	76,628	1904	219,446
1874	4,070	1890	133,180	1905	289,983
1875	6,993	1891	127,766	1906	300,500
1876	5,907	1892	179,131	1907	339,348
1877	7,897	1893	81,118	1908	152,018
1878	9,530	1894	120,180	1909	225,040
1879	12,438	1895	171,724	1910	226,216
1880	17,503	1896	131,940	1911 [1]	178,615
1881	18,827	1897	173,695	1912 [1]	227,939
1882	19,610	1898	213,769	1913 [1]	226,475
1883	21,941	1899	219,768	1914 [1]	177,356
1884	30,262	1900	255,977	1915 [1]	258,816
1885	30,956	1901	291,461		
1886	42,841	1902	212,934		5,731,860
1887	42,498				

For the five-year period 1910–1914 the average annual imports of ferromanganese have been almost equal to domestic production, but for 1915 the domestic production was 72 per cent and imports only 28 per cent of the supply.

The price of ferromanganese for immediate delivery rose steadily from $80 a ton at the beginning of the year to $115 at the close. The price of English ferromanganese, which is usually sold under contract, was slightly lower than the prices stated above.

The embargo which was placed upon the export of ferromanganese by the English Government in November, 1914, was lifted early in 1915, and the first shipment was received in the United States in March. The table following was compiled from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

[1] Marketed production. Figures collected by United States Geological Survey.

Ferromanganese and spiegeleisen imported for consumption in the United States, 1903–1915.

Year.	Ferromanganese.		Spiegeleisen.		Total.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1903	41,519	$1,699,666	122,015	$2,709,317	163,534	$4,408,983
1904	21,813	707,037	4,623	132,461	26,436	839,498
1905	52,841	1,884,651	55,457	1,336,104	108,298	3,220,755
1906	84,359	4,953,644	103,268	2,942,940	187,627	7,896,584
1907	87,400	5,354,656	48,994	1,399,381	136,394	6,754,037
1908	44,624	1,860,664	4,579	125,054	49,203	1,985,718
1909	88,934	3,396,381	16,921	356,447	105,855	3,752,828
1910	114,228	4,341,071	25,383	489,049	139,611	4,830,120
1911	80,263	3,015,062	20,970	405,444	101,233	3,420,506
1912	99,137	3,906,920	1,015	28,094	100,152	3,935,014
1913	128,070	5,682,915	77	2,173	128,147	5,685,088
1914	82,997	3,619,607	2,870	71,147	85,867	3,690,754
1915	55,263	3,333,699	200	5,110	55,463	3,338,809
	981,448	43,755,973	406,372	10,002,721	1,387,820	53,758,694

VALUE OF MANGANESE ORES.

The value of the materials that contain manganese depends largely on the percentage of metallic manganese, and also both on the manganese minerals present and the condition or state of aggregation of the material. As the manufacture of the manganese alloys, ferromanganese and spiegeleisen, is a well-established industry in which a large quantity of ore is used every year, the market for ores adapted to this use is relatively stable, but it fluctuates with the consumption of steel. Within the last 25 years the demand for dry batteries and consequently for the manganese ore used in making them has grown tremendously, so that the market for this grade of ores is fairly stable under normal industrial conditions. It is estimated that the present demand for manganese ore for dry batteries alone is about 20,000 tons a year. A similar grade of manganese ore is used in the flint-glass industry. The market for other grades of manganese-bearing materials, such as are used in making high manganese pig iron, paints, and driers, is less stable, for the consumers are few and the changes in the technology of the processes used are frequent.

The value of the manganese ore used in the manufacture of ferromanganese in the United States corresponds approximately, under normal conditions, with the prices in the English, French, Belgian, and German markets, when allowance is made for the difference in freight rates between the mines and the place of delivery. This is true because the furnaces of these countries derive most of their ore from the same countries that supply the United States. The prices paid for this grade of ore in the United States are governed largely by the specifications announced from time to time by the Carnegie Steel Co., of Pittsburgh, Pa. The specifications now in use are given below:[1]

Schedule of prices paid per ton of 2,240 pounds for domestic manganese ore delivered at Pittsburgh or Bessemer, Pa., and South Chicago, Ill.

Prices are based on ores containing not more than 8 per cent silica or 0.20 per cent phosphorus and are subject to deductions as follows: For each 1 per cent in excess of

[1] Circular issued by Carnegie Steel Co., Aug. 21, 1915.

8 per cent silica there shall be a deduction of 15 cents per ton; fractions in proportion.

For each 0.02 per cent, or fraction thereof, in excess of 0.20 per cent phosphorus there shall be a deduction of 2 cents per unit of manganese per ton.

Ores containing less than 40 per cent manganese or more than 12 per cent silica or 0.225 per cent phosphorus are subject to acceptance or refusal at the buyer's option.

Settlements are based on analysis of sample dried at 212° F., the percentage of moisture in the sample as taken being deducted from the weight.

Percentage of metallic manganese in ore.	Price per unit of manganese in cents.
Over 49	45
46 to 49	43
43 to 46	40
40 to 43	36

According to these specifications the price paid for ores in 1915 ranged from $14.40 to $22.05 a ton.

The value of an ore adapted to use as an oxidizer in dry batteries and flint glass varies with its content of manganese dioxide, and in contradistinction to those used in metallurgical industries does not depend, except indirectly, on its content of metallic manganese. As much of the ore of the Caucasus region contains from 85 to 92 per cent manganese dioxide and less than 1 per cent iron and is therefore admirably adapted to these uses, most specifications for ores to be put to these uses are such as can be met by ores from the Caucasus region but only rarely by ores from other regions. According to one manufacturer of dry batteries, as long as Caucasian ore was available there was little experimentation to determine the suitability of the several manganese minerals and the limits beyond which other elements than manganese may be present. As a result of recent experiments, it has been shown that copper, nickel, and cobalt are the most harmful elements in the ordinary dry battery and should not be present in even minute quantities. A few tenths of 1 per cent of any of these elements renders an ore unfit for this use. On the other hand, it is stated that more than several per cent of iron as oxide does not greatly affect the efficiency of a battery and that the 1 per cent limit is arbitrary. In the absence of an established schedule, such as exists in the steel industry, most of the ore is supplied to the dry-battery makers by brokers in lots ranging from 5 to 100 tons under guaranteed specifications. On account of the temporary elimination of Caucasian ore prices have risen, and it is reported that as much as $85 a ton has been paid by eastern consumers. Few of the known deposits of the United States are capable of producing more than a small quantity of ore that contains less than 1 per cent iron and a trace of copper, nickel, and cobalt.

The value of manganiferous iron ores and manganiferous silver ores depends on local conditions in the metallurgical industries that consume them, as the manganese content is used only indirectly. The prices paid for manganiferous iron ores containing 15 to 35 per cent manganese range from $3.50 to $6 a ton. Manganiferous silver ores are of value as fluxes principally for their content of iron, silver, and metals other than manganese, which only rarely adds more than $3 a ton to their value.

The more impure ores, such as will serve for coloring glass and pottery, are sold at prices ranging from $2 to $6 a ton f. o. b. works. Producers supply the greater part of these ores directly to the trades and prices are wholly subject to contract. Manganiferous zinc residuum is not sold in the open market, but is smelted to spiegeleisen by the company that produces it.

DOMESTIC MANGANESE DEPOSITS.

Arizona.—The Bunker Hill Mines Co. shipped ore from the Lucky Cuss, Oregon, and Escondido mines, at Tombstone, Ariz. A part of this ore was high-grade dioxide, low in iron oxide and available for chemical uses, including the manufacture of dry batteries.

California.—The mines of California reported for the year 1915 the largest production of manganese ore yet recorded for the State, 2,563 long tons. This was largely due to the activity of the Thomas mine, near Ukiah, Mendocino County, which shipped ore to the Noble Electric Steel Co., at Heroult, Shasta County. Other mines in Shasta County, in the Livermore-Tesla district, Santa Clara and San Joaquin counties, and near Zabriskie, Inyo County, produced small quantities of ore during the year.

The Noble Electric Steel Co. produced ferromanganese in electric furnaces. The product was shipped to eastern steel mills.

Colorado.—The deposits of manganese ore near Norwood, San Miguel County, Colo., which were discovered in 1914, were further explored during 1915 and a small quantity of high grade dioxide ore was shipped.

Minnesota.—The manganiferous iron ores of the Cuyuna range, Minn., have been described recently by E. P. McCarty.[1] The ores occur in lenses that form two parallel belts that are known as the North and the South ranges, respectively. The inclosing rocks are slate of Algonkian age. Along the North range, which has been explored for a distance of 10 miles, the average width of the lenses does not exceed 300 feet, but a maximum width of 500 feet is attained. Minable ore has been explored to a depth of 450 feet. Along the South range, which has been explored for a distance of about 25 miles, the average width of the lenses is about 50 feet and a maximum of 125 feet is attained. Minable ore is known to an average depth of 300 feet along this range. The manganiferous ores appear to be confined to the North range.

In general, the content of iron and manganese decreases and that of silica increases as depth is attained. The iron occurs as red, brown, and black hydrated hematite, which is locally earthy and is thought to have been derived from ferruginous carbonate minerals. The moisture content of the ores ranges from 6 to 14 per cent, the average being about 12 per cent. According to the phosphorus content, two classes of ores are recognized. The high phosphorus ores contain from 0.20 to 0.32 per cent phosphorus, 38.74 to 51.16 per cent iron, 6.61 to 16.23 per cent manganese, 3.21 to 6.07 per cent silica, and 2.35 to 3.66 per cent alumina. No way is known by which this class of ore can be treated with the view to reducing the phosphorus which probably exists as vivianite and apatite. The

[1] McCarty, E. P., Manganiferous iron ores of the Cuyuna range: Eng. and Min. Jour., vol. 100, pp. 400–402, 1915,

low-phosphorus ores contain less than 0.1 per cent phosphorus and the average percentages of the other ingredients are similar to those of the high-phosphorus ores.

There are no ores on the Cuyuna range from which standard grades of ferromanganese may be made. From those ores that are richest in manganese spiegeleisen is now being made, but the high-phosphorus ores can not be used for this purpose.

The production of manganiferous iron ores from the Cuyuna range for 1915 was the largest on record.

Utah.—High-grade manganese dioxide ore was mined in Emery and Grand counties, Utah, 10 miles south of Floy Siding and 18 miles southeast of Green River, on the Denver & Rio Grande Railroad.

Virginia.—Reports have been received from 35 owners or operators of manganese mines in Virginia during 1915, of which mines 7 reported a production, 8 have been prospected with the view to producing, and 20 were idle. The discovery of a deposit is reported in Shenandoah County, and several old mines were reopened. Although the production of ore was larger than in 1914, it is scarcely so large as might have been expected from the activity among the mines in the spring months of 1915.

The Crimora Manganese Corporation continued to make preparations at the Crimora mine for operation on a large scale, but did not produce ore after taking over the mine from the previous operators. The Oxford Mining & Manganese Corporation gave up operations on the Myers mine, in Campbell County, but the owner, D. W. Myers, continued exploration. The Seibel mine, at Happy Creek, Warren County, was operated for several months and shipped both manganese and manganiferous iron ores. H. P. Binswanger & Co. mined high-grade dioxide ore from the Powell's Fort mine in Shenandoah County.

Thomas [1] reviews the manganese-ore industry in the Southern States and concludes that a large aggregate tonnage exists in the numerous deposits that are known, and that by proper administration, companies may be able to operate successfully several neighboring mines, which if operated singly could not be made to pay.

Hewett [2] describes the occurrence in Virginia of ore at the Piedmont or Myers mine, Campbell County; Midvale mine, Rockbridge County; Lyndhurst mine, Augusta County; Kendall & Flick mine, Rockingham County; Happy Creek mine, Warren County; and in Maryland at the Dargan mine, Washington County. The hypothesis that the manganese deposits of the Piedmont and Great Valley regions were formed during the period of peneplanation of early Tertiary time is suggested. It is noted that the greatest depth below this peneplain to which ore has been mined is about 410 feet and the tentative conclusion is reached that the important masses of manganese ore lie within 300 feet of the peneplain.

Washington.—Reports have been received [3] that manganese ore of good grade has been discovered at several localities near Humptulips, Grays Harbor County, Wash.

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[1] Thomas, Kirby, Southern manganese mining not satisfactory: Min. and Eng. World, 1915, p. 853.

[2] Hewett, D. F., Some manganese mines in Virginia and Maryland: U. S. Geol. Survey Bull. 640, pp. 37–71, 1916 (Bull. 640-C).

[3] Letters from Philip S. Locke, Aberdeen, Wash., and Clarke H. Pealer, Denton, Kans.

FOREIGN MANGANESE DEPOSITS.

General.—A very interesting pamphlet, which assembles much information on manganese ore not easily accessible, has been recently published.[1] Although manganese minerals and the important deposits of the world are briefly described, the greatest value of the pamphlet lies in the numerous tables of production and exports of ore to the countries that produce and of production and imports of the countries that consume manganese ore. Most of these tables cover periods since 1901. Unfortunately no references are given, and some of the tables do not show the units used. The table showing production of ore in the world gives the production of many European countries in metric tons and that of India in long tons, although no reference is made to the fact.

The manganese industry of the Caucasus region is described in detail, and in addition to production, exports, and stocks of ore, tables are presented that show for each year the number of producing mines and the number of miners and employees.

Brazil.—Harder[2] describes the manganese deposits of central Minas Geraes, Brazil, and recognizes two classes of deposits. In one class psilomelane and wad, with associated clay, form large irregular lenses that are inclosed in or bounded by gneiss, granite, or schist. The most important deposit of this class in Brazil is worked at Morro da Mina, near Lafayette. In these deposits the manganese oxides are thought to have been derived by processes of weathering from manganese silicates and carbonates, such as tephroite, spessartite, rhodonite, and rhodochrosite, which occur in the gneiss and schist. In the other class of deposits finely crystalline and amorphous manganese oxides that are probably mixtures of pyrolusite and psilomelane, form beds in metamorphosed sediments which overlie the gneiss and schist that inclose the other class of deposits. The beds of manganese ore attain a maximum thickness of about 6 feet. It is thought that the manganese oxides have been derived from the deposits in the underlying gneiss and schist. The Wigg mine, near Miguel Burnier, is the most important that operates a deposit of this class.

Cuba.—The Cauto Mining Co. operated the Abundancia mine, at San Nicolas, Province of Oriente, throughout the year and shipped regularly. The company also carried on explorations at the Llave mine, near San Nicolas, and the San Andrea, 1½ miles from East San Luis.

During the last months of 1915 J. Cendoya and associates reopened the La Gloria mine, near San Luis. There was considerable prospecting elsewhere in the vicinity of Santiago during 1915.

India.—The production of manganese ore in India during 1914 was 682,898 long tons,[3] which was approximately equal to that of the preceding three years. The records of production up to July, 1915, however, show a great decline, and it is probable that the production for the year will be less than one-third of the normal.

A comprehensive review of the industry for the five-year period 1909–1913 has recently been issued.[4]

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[1] Fach, E., Le minéral de manganèse, 44 pp., Paris, H. Dunod & E. Pirat, 1914.
[2] Harder, E. C., The geology of central Minas Geraes, Brazil: Jour. Geology, vol. 23, pp. 404–406, 1915.
[3] India Geol. Survey Rec., vol. 45, pt. 3, p. 171, 1915.
[4] Quinquennial review of the mineral production of India: India Geol. Survey Rec., vol. 46, pp. 135–179, 1915.

Newfoundland, Canada.—N. C. Dale [1] has described the occurrence of manganese ore along the north shore of Newfoundland near Manuels, Topsail, Long Pond, Chapel Cove, and Briggs, on Conception Bay; on Smith Sound; on Trinity Bay; and on Placentia Bay. It is stated that the manganese minerals and the interbedded bands of jasper form zones 20 to 30 feet wide in a group of red and green shale and limestone of Lower Cambrian age. The occurrence of disseminated grains of complex manganese carbonates is noted. The conclusion is reached that the ore-bearing bands are altered marine sediments.

The shipment of ore from the Birgus locality is noted.[2]

Panama.—Preparations were made during the later months of 1915 for the reopening of the Novedad and near-by manganese mines at Nombre de Dios, Panama.[3]. No ore has been shipped from the mines since 1901.

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[1] Manganese deposits of Conception and Trinity Bays [Newfoundland]: Geol. Soc. America Bull., vol. 25, pp. 73–74, 1914.
[2] Eng. and Min. Jour., vol. 100, p. 543, 1915.
[3] Personal communication from Mr. Charles Hedges, Washington, D. C.

SILVER, COPPER, LEAD, AND ZINC IN THE CENTRAL STATES.

(MINES REPORT.)

By J. P. Dunlop and B. S. Butler.

INTRODUCTION.

By J. P. Dunlop.

The following is an account of the production of silver, copper, lead, and zinc in 1915 by the mines of the Central States, including Arkansas, Illinois, Kansas, Kentucky, Michigan, Missouri, Oklahoma, and Wisconsin. The territory thus embraced lies in the great interior valley province of the United States which extends from the Appalachian system to the Rocky Mountain front, excluding the Black Hills. Most of the mines are developed in the Paleozoic sedimentary rocks of this province, but the copper range of northern Michigan comprises lavas and intercalated sediments of pre-Cambrian age.

The statistics of production in this country have been compiled by the United States Geological Survey from confidential reports by each mine in operation and represent the quantity of metals recovered or paid for in the ore that was treated or sold during the year.

The method of marketing and recording the mine output in the lead and zinc regions of the United States differs from that employed in the Western States. In the Western States the miner usually sells his ore according to the assay content of metal at a certain price per unit. In the lead and zinc regions of the Central States, however, where the material sold is principally concentrates,[1] payment is made according to a basis price for a certain quality of concentrates. The details of this method are given in the pages devoted to Missouri in this report for 1914. The figures reported to the Survey by producers represent the quantity and assay content of concentrates sold and the amount received in payment. The total metal produced is calculated from the first two of these items.

The operators in Michigan report the quantity of concentrates produced and the actual recovery of copper from concentrates smelted.

In any year the mines may produce more or less concentrates than are smelted during the same period. The copper content of concentrates produced during the year but not smelted has been estimated on the basis of the average copper recovery per ton for the year of the company producing it.

[1] In local usage the ore as mined is called "dirt" and the concentrates are classed as "ore." Where the capacity of a concentrating plant is given, such capacity is to be understood as based on a 10-hour shift unless otherwise stated.

TENOR OF LEAD AND ZINC ORES OF THE CENTRAL STATES.

Much of the ore mined in the Western States is crude smelting ore; that is, it can be smelted directly without preliminary concentration. All but a very small portion of the ore from the Central States is of such tenor that it requires concentration. The only fair basis for comparison of the relative magnitude of mining operations in different States is that of quantity of crude ore, or "dirt," as it is usually called in the lead and zinc regions of the Central States. However, in those States it is only the larger companies which make any record of the crude ore raised. In the Joplin and upper Mississippi Valley regions the number of cans of ore hoisted is usually recorded and the approximate weight of the cans is generally known. Thus each company knows, in a general way, about what percentage of concentrates the run of mine is yielding. Knowing the total production of concentrates and the average yield of concentrates from crude ores, one can arrive at a close estimate of the crude ore raised. Only the actual operating companies have the data, however, and it was the practice of the Survey, in order to shorten the list of producers as much as possible, to send requests only to the owners of the mining land or the companies holding first leases and to depend upon them to report the whole production of the tract. Since 1911 not only the first lessees of the land reported to the Survey, but also most of the sublessees have given data regarding both concentrates produced and "dirt" or ore milled. The tables of tenor of ore which follow in the sections devoted to the respective States show the comparative percentages for the last three years.

In Kentucky and southern Illinois the lead and zinc concentrates are recovered as by-products in the concentration of the fluorspar which they accompany and it was not possible to make calculations of the metal content of the crude ore raised.

Tenor of copper, lead, and zinc ores of Central States, 1913–1915.

State.	1913		1914		1915	
	Crude ore.	Metal content.[a]	Crude ore.	Metal content.[a]	Crude ore.	Metal content.[a]
	Short tons.	*Per cent.*	*Short tons.*	*Per cent.*	*Short tons.*	*Per cent.*
Arkansas	13,000	4.44	20,000	4.10	110,000	3.31
Illinois (northern)	119,200	2.9	261,300	2.49	316,000	2.35
Kansas	590,300	2.3	540,500	2.58	709,400	2.42
Michigan	7,016,370	.968	9,269,413	.89	12,334,700	1.07
Missouri	[b] 12,309,000	2.45	11,492,300	2.70	15,573,700	2.32
Oklahoma	581,100	3.57	763,920	3.02	891,800	2.68
Wisconsin	1,406,000	2.73	1,387,490	2.91	1,934,000	2.77
	22,034,970	.....	23,734,923	.....	31,869,600	.....

[a] The percentages given in this column represent the metal content of the ore in so far as it is recovered in the concentrates. In Michigan the metal so recovered is copper; in the other Central States the metals are lead and zinc, the relative proportions of which are shown in the table on another page and in the tables of tenor of ore given in the sections devoted to the respective States.

[b] A small quantity of copper ore included.

This table shows that from the silver, copper, lead, and zinc mines of the Central States an increase of about 8,135,000 short tons of ore was treated in 1915. The production of ore from the copper mines

of Michigan increased more than 3,000,000 tons and the ore production in Missouri increased more than 4,000,000 tons, an increase due mainly to the "sheet ground" mines, though the mines of the disseminated lead district in southeastern Missouri increased their output about 350,000 tons. All the other States had a notably larger output of ore, Arkansas and Wisconsin showing the largest proportionate increases.

The quantity of ore mined and treated from copper, lead, zinc, and lead-zinc mines in the Central States in 1915 was approximately 55 per cent of the total ore of that description sold or treated by mines in the United States in 1914 and was 28 per cent of all the metallic ores from domestic mines sold or treated in 1914.

The low average tenor of the metal content of crude ore mined in the Central States in 1915 is best shown by the fact that the average value of the recoverable metal content was only $3.80 per ton of crude ore treated, and this value is $1.47 more than it was in 1914. The 19,534,900 tons of zinc, lead, and lead-zinc ores treated in the Central States in 1915 yielded lead and zinc concentrates which sold for $45,582,098, so that the mine operators realized an average of $2.33 a ton of ore mined and treated, against $1.64 realized for a ton of ore in 1914. This large increase of 42 per cent does not represent the entire gain, for in many cases the extraordinary prices paid for ore made possible the mining of ores that could not possibly have been mined profitably under normal conditions.

PRODUCTION.

The total value of the mine production of silver, copper, lead, and zinc in the Central States in 1915 was $121,283,262, an increase of $66,111,956, or 120 per cent, compared with the value for 1914. The total value of the production of these metals for the years 1907 to 1915, inclusive, was $639,550,811, of which $284,890,055 was for copper, $207,424,470 for zinc, $145,070,902 for lead, and $2,165,384 for silver.

SILVER.

The production of silver in the Central States in 1915 was 647,553 fine ounces, which, at the average price of 50.7 cents per fine ounce (4.6 cents lower than in 1914), was valued at $328,309, as compared with 482,983 fine ounces, valued at $267,089, in 1914. Nearly all the silver that is produced in the Central States is recovered incidentally in the production of other metals. Of this production 585,933 ounces came from the copper lodes of Michigan, an increase of 172,433 ounces resulting from a much larger copper output. About 23 per cent of the concentrates from lead ores mined in southeastern Missouri was desilverized and yielded nearly all the silver from that State recovered in 1915; a small output of silver was also derived from copper ore, and the total recovery from Missouri amounted to 57,756 ounces.

The lead-zinc-fluorspar deposits of the Kentucky-Illinois field also carry silver, and from the lead concentrates derived from Illinois 3,864 ounces of silver were recovered, an increase of 1,752 ounces.

COPPER.

The mine production of copper in the Central States in 1915 was from Michigan and Missouri, the first-named State, as in other years, contributing nearly the entire output, which amounted to 265,685,538 pounds. The copper production of Michigan in 1915 was 265,283,378 pounds, which, at the average New York price of 17.5 cents a pound, was valued at $46,424,591, as against a yield of 164,344,058 pounds, valued at $21,857,759, in 1914. The copper produced in Missouri in 1915, amounting to 402,160 pounds, valued at $70,378, was derived mainly from concentrates recovered in dressing the lead ores of southeastern Missouri, but part came from matte carrying copper and silver, which was shipped from the smelter of the Missouri Copper Mountain Mining Co.

No shipments were reported from the old prospects near Dunbarton, in Lafayette County, southwestern Wisconsin.

The total mine production of copper from Michigan and Missouri in 1915 was 101,286,717 pounds more than in 1914, and was 31,550,000 pounds more than the output of any one year since 1907.

LEAD.

The mine production of lead in the Central States in 1915 was 222,548 short tons, which, rated at the average New York price for the metal for the year of 4.7 cents a pound ($94 a ton), was valued at $20,919,512, as compared with 203,845 short tons, valued at $15,899,910, in 1914. The output of lead increased 18,703 tons in 1915, and the value increased $5,019,602. In 1915 Missouri produced 95 per cent of the yield of lead in the Central States, and the recoverable lead content of galena and lead carbonate concentrates mined in Missouri in 1915 equaled 41 per cent of the refined primary lead recovered in the United States from domestic ore. Of the total output of lead in Missouri the "disseminated lead" district of southeastern Missouri produced 183,454 tons, an increase of 15,440 tons, again exceeding the yield from the Coeur d'Alene district of Idaho and retaining first place in lead production in the United States. Southwestern Missouri was the next largest producing district in the Central States, with an output of 26,534 tons, or 1,936 tons more than in 1914. The increase in this district was wholly due to the increased mining of "sheet ground," as the production from the "soft ground" and shallow mines was about 2,000 tons less than in 1914. The Oklahoma production decreased from 7,556 tons in 1914 to 7,306 tons in 1915, and its output was double that of Wisconsin and Kansas. The output of lead in 1915 from mines in Illinois, Wisconsin, and Kentucky was considerably greater than it was in 1914 and that from Kansas was about 200 tons less.

ZINC.

The production of zinc in the Central States in 1915, based on mine returns with a deduction for separating and smelting losses, was 215,889 short tons, valued at $53,540,472. The value is computed at 12.4 cents per pound of spelter ($248 per ton), the average sales price reported by the smelters for the metal.

The output in 1915 is the largest recorded yield from mines in the Central States, exceeding that of the year 1912 by 27,582 tons in quantity and by more than $27,000,000 in value, and the production of 1914 by 47,857 tons in quantity and $26,401,208 in value. The production of spelter in the Central States was about 47 per cent of the total production of primary spelter from domestic ores in the United States in 1915, as compared with 49 per cent in 1914.

The State of Missouri, with an increased output of 30,306 tons, was again in 1915 much the largest producer of zinc in the United States. Its production was 136,300 tons, against 105,994 tons in 1914. Wisconsin produced 41,403 tons in 1915, against 31,113 tons in 1914. Arkansas increased in output from 608 tons to 3,209 tons, Illinois from 4,811 tons to 5,534 tons, Kansas from 11,284 tons to 14,365 tons, Kentucky from 230 tons to 764 tons, Oklahoma, which had increased from 11,664 tons in 1913 to 13,992 tons in 1914, increased to 14,314 tons in 1915.

SUMMARY OF PRODUCTION BY STATES.

Mine production of silver, copper, lead, and zinc in the Central States in 1915.

State.	Silver.		Copper.	
	Quantity.	Value.	Quantity.	Value.
	Fine ounces.		*Pounds.*	
Illinois	3,864	$1,959		
Michigan	585,933	297,068	265,283,378	$46,424,591
Missouri	57,756	29,282	402,160	70,378
	647,553	328,309	265,685,538	46,494,969
Total, 1914	482,983	267,089	164,398,821	21,865,043

State.	Lead.		Zinc.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Short tons.		*Short tons.*		
Arkansas	63	$5,922	3,209	$795,832	$801,754
Illinois	954	89,676	5,534	1,372,432	1,464,067
Kansas	1,212	113,928	14,365	3,562,520	3,676,448
Kentucky	251	23,594	764	189,472	213,066
Michigan					46,721,659
Missouri	210,440	19,781,360	136,300	33,802,400	53,683,420
Oklahoma	7,306	686,764	14,314	3,549,872	4,236,636
Wisconsin	2,322	218,268	41,403	10,267,944	10,486,212
	222,548	20,919,512	215,889	53,540,472	121,283,262
Total, 1914	203,845	15,899,910	168,032	17,139,264	55,171,306

LEAD AND ZINC PRODUCTION, BY REGIONS.

The productive lead and zinc territory in the Central States naturally falls into seven regions, three of which are not limited to any single State. For statistical purposes the tables showing the production of lead and zinc by States are necessary and are so given For practical purposes, however, it is desirable to compile the production by the natural regions irrespective of State lines.

The seven regions are as follows, in order of importance of output: (1) The Joplin region, comprising the district in southwestern Missouri, southeastern Kansas, and northeastern Oklahoma; (2) southeastern

Missouri, containing the great disseminated lead deposits; (3) the upper Mississippi Valley region, including all the lead and zinc mines in southwestern Wisconsin, Iowa, and northwestern Illinois; (4) northern Arkansas; (5) the Kentucky-Illinois fluorspar region in southern Illinois and northern Kentucky; (6) central Missouri;[1] (7) the Arbuckle Mountain region in southern Oklahoma.

The southeastern Missouri region produced about 83 per cent of the lead output of the Central States and about 34 per cent of the production of primary lead recovered from domestic ore smelted or refined in the United States in 1915. The Joplin region produced 16 per cent of the lead and 76 per cent of the zinc of the Central States in 1915, and was much the largest producer of zinc in the United States, yielding about 36 per cent of the total spelter production from domestic ores in 1915, as against 38 per cent in 1914. The upper Mississippi Valley region produced a little more than 1 per cent of the lead and 22 per cent of the zinc in the Central States in 1915. The production of zinc in the northern Arkansas region showed a substantial increase and amounted to about 2 per cent of that of the Central States in 1915.

Mine production of lead and zinc in the Central States in 1915.

Region.	Concentrates.				Total value of concentrates.
	Lead.[a]		Zinc.[b]		
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
Joplin	45,350	$2,397,566	321,695	$23,419,103	$25,816,669
Southeastern Missouri [c]	278,104	12,773,579	1,104	40,524	12,814,103
Upper Mississippi Valley	3,854	203,184	162,029	6,132,816	6,336,000
Northern Arkansas	79	4,961	8,531	449,420	454,381
Kentucky-Southern Illinois	1,011	44,954	2,172	106,079	151,033
Arbuckle Mountain, Okla			132	9,912	9,912
Total, 1914	328,398	15,424,244	495,663	30,157,854	45,582,098
	294,124	11,796,121	390,213	11,863,420	23,659,541

Region.	Metal.				Total values of metal.
	Lead.		Zinc.		
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
Joplin	35,052	$3,294,888	164,544	$40,806,912	$44,101,800
Southeastern Missouri [c]	183,906	17,287,164	372	92,256	17,379,420
Upper Mississippi Valley	2,817	264,798	46,937	11,640,376	11,905,174
Northern Arkansas	63	5,922	3,209	795,832	801,754
Kentucky-Southern Illinois	710	66,740	764	189,472	256,212
Arbuckle Mountain, Okla			63	15,624	15,624
Total, 1914	222,548	20,919,512	215,889	53,540,472	74,459,984
	203,845	15,899,910	168,032	17,139,264	33,039,174

[a] Includes both galena and lead carbonate concentrates.
[b] Includes sphalerite, zinc carbonate, and zinc silicate concentrates.
[c] Includes a small production from the central Missouri region.
[1] Owing to the small output from the central Missouri region it has in this report, for convenience, been included in the southeastern Missouri region.

The volume of Mineral Resources for 1914 contains brief reviews of the history of lead and zinc mining in the Central States, the yearly production of each State for the period 1907 to 1914, inclusive, and historical notes and estimates of the total production of lead and zinc produced in each State before 1907. The separate chapter entitled "Silver, copper, lead, and zinc in the Central States in 1914" can be obtained on application to the Director, United States Geological Survey, Washington, D. C.

ARKANSAS.

By J. P. Dunlop.

PRODUCTION.

The value of the recoverable lead and zinc from Arkansas mines increased from $65,214 in 1914 to $801,754 in 1915. This was a larger proportionate increase than in any other Central State. There was no notable increase in the output of galena or of sphalerite, but the shipments of zinc carbonate and silicate were exceeded only by that of Missouri and the development work done indicates that the Arkansas output of the last mentioned ores will continue to increase in 1916.

Mine production of lead and zinc in Arkansas, 1907–1915.[a]

Year.	Ore.						Metal content.			
	Lead concentrates (galena).		Zinc concentrates.				Lead.		Zinc.	
			Sphalerite.		Silicate and carbonate.					
	Quantity (short tons).	Value.	Quantity. (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1915	79	$4,961	606	$41,341	7,925	$408,079	63	$5,922	3,209	$795,832
1914	52	2,408	743	19,406	1,143	25,187	41	3,198	608	62,016
1913	23	1,179	594	16,916	680	15,050	18	1,584	478	53,536
1912	39	2,180	1,419	56,235	462	11,231	31	2,790	748	103,224
1911	80	4,321	1,407	40,425	183	4,239	64	5,760	664	75,696
1910	80	3,714	1,857	74,136	128	2,641	63	5,544	994	107,352
1909	30	1,800	896	33,948	98	2,736	24	2,064	510	55,080
1908	18	985	516	18,270	939	21,469	15	1,260	605	56,870
1907	15	800	538	15,233	663	16,210	12	1,272	474	55,932

[a] In calculating the metal content of the ores from assays allowance has been made for smelting losses in the case of zinc but not in case of lead. In comparing the values of ore and of metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily quotations at New York, and that of zinc from the average sales price reported by the smelters.

Tenor of lead and zinc ore and concentrates produced in Arkansas in 1914 and 1915.

	1914	1915
Total crude ore, short tons	20,000	110,000
Total concentrates in crude ore:		
Lead, per cent	.26	.07
Zinc, do	9.4	7.76
Metal content of crude ore:		
Lead, do	.2	.06
Zinc, do	3.9	3.25
Average lead content of galena concentrates, do	78.9	79.8
Average zinc content of sphalerite concentrates[a], do	44.7	59.6
Average zinc content of zinc silicate and carbonate[a], do	40.0	40.6
Average value per ton:		
Galena concentrates	$46.31	$62.80
Sphalerite concentrates	$26.12	$68.21
Zinc silicate and carbonate	$22.04	$51.49

[a] Includes some mixed carbonate and sphalerite.

NORTHERN ARKANSAS.

Considerable prospecting and some mining was carried on for many years, but the present development has mainly been accomplished since 1899, when there was a great rush to the northern Arkansas field. The mines are principally in Boone and Marion counties and in the adjoining portions of Searcy and Newton counties, though there are also numerous mines and prospects in Baxter, Izard, Sharp, Lawrence, and other counties to the east, and deposits have been worked in Washington and Sevier counties, on the extreme western border of the State.

The ores are galena, sphalerite, and smithsonite, and the concentrates produced are generally of high grade and free from or very low in iron or lime. The sphalerite has frequently assayed 2 or 3 per cent above the price basis of 60 per cent metallic zinc content. The sphalerite and smithsonite are shown by analysis to contain appreciable quantities of cadmium, especially in a yellow variety of smithsonite, known locally as "turkey fat," which shows as high as 0.8 per cent of cadmium. The ore bodies occur in fissures or crevices, in fault breccias, and in solution breccias. The ore deposits are for the most part found in limestone of early Ordovician age, but some also are found in the Boone limestone of Mississippian (lower Carboniferous) age.

In 1913 and 1914 nearly all the zinc concentrate classed as sphalerite was mixed sphalerite and zinc carbonate mined from shallow workings. In 1915, however, there was less of this mixed ore sold, because the smelter demand was especially for zinc carbonate ores, which do not require to be given a preliminary roasting before being smelted. Carbonate concentrates were assayed for sulphur content, and a lower base price was quoted for concentrates containing any appreciable quantity of sulphur. Consequently the quantity of mixed concentrates produced at the mines was lessened by more careful sorting of the ore.

The prevailing high prices stimulated the mining of carbonate ores, but it had the opposite effect regarding the production of sphalerite, for the yield of this kind of ore in 1915 was less than in 1914 and much of the comparatively small output was marketed in the early part of the year. This was a natural result, for the greater part of the Arkansas production of zinc was that of individuals or companies having small capital. The zinc carbonate ore bodies were easily developed and hand-cobbed concentrates were shipped, while "mill dirt" accumulated until it could be custom milled or a sufficient quantity was on the dump to warrant the expense of constructing a concentrating plant.

The production in 1914 was that of less than 30 mines or prospects, that of 1915 of nearly 100 mines or prospects. The entire district awakened from the lethargy which had prevailed for years and capital from outside the State was added to that of local investors. Old mills were refitted and new plants were contracted for, a few of which were completed in time to augment the production in 1915.

The prices paid for zinc concentrates were as high as in districts more favorably situated, so that the only handicaps were the bad roads and the unusual floods, which hindered the transportation of concentrates, supplies, and mill equipment. The increasing impor-

tance and prosperity of the mining interests made it necessary to obtain better transportation for the territory between Yellville and the Rush camp. Surveys were made for proposed railways between Cotter and Rush and between Yellville and Rush, both of which would connect Rush with the White River branch of the St. Louis, Iron Mountain & Southern Railway. The line from Rush to Yellville, a narrow-gage railway, is now under construction and probably will be completed during the summer of 1916.

The town of Rush has grown from a sleepy village of a few hundred inhabitants to a thriving mining camp, in which it has been difficult to obtain adequate supplies because of extremely bad roads. About 18 concentrating plants were operated in Arkansas steadily or during part of the year 1915, as compared with 4 plants in 1914, and the output of these concentrating plants amounted to about 50 per cent of the total production shipped in 1915. Wood was universally used for fuel and, although there is a good supply near most camps, it is difficult to arrange for an adequate supply to run the plants and to provide a reserve for emergencies occasioned by long periods of bad roads. Some operators state that the problem of a fuel supply requires more time and thought than the difficulties relating to mining and milling the ore. One plant in the Rush district has already been equipped for burning fuel oil and others will adopt oil engines when the railway makes possible the use of tank cars.

There were many transfers of mining lands in all districts, and leases were made at reasonable royalties. Moreover, the present investors are avoiding the unfortunate errors made in the first boom of erecting expensive concentrating plants and other surface decorations before developing sufficient ore bodies.

That zinc carbonate ores can be located and profitably mined in many places in northern Arkansas has been proved. Many of these ore bodies are too small for milling plants, but they are easily worked at small expense. The hand-cobbed ore is readily sold and the mill dirt can be treated at custom plants, one of which is now operated at Zinc. As more of these small properties are opened, other custom plants will be erected.

Whether the mining of sphalerite ore will become as extensive or as profitable as that of zinc carbonate has not been demonstrated. It assuredly has not been so up to the year 1916; but it is hoped that ample capital under capable management will so develop some of the sphalerite mines that the mills can be started with sufficient ore blocked out to insure steady operation.

The shipments of lead concentrates from mines increased from 52 tons in 1914 to 79 tons in 1915. The production of sphalerite concentrates was 606 tons, or 137 tons less than in 1914, but the value increased from $19,406 in 1914 to $41,314 in 1915. The sales of zinc carbonate concentrates increased from 1,143 tons, valued at $25,187, in 1914, to 7,925 tons, valued at $408,079, in 1915. Mines in Marion, Boone, Newton, Searcy, Baxter, and Lawrence counties produced all the zinc concentrates sold in 1915, and 86 per cent of the galena concentrates sold were mined in Newton County.

Mines in Baxter and Lawrence counties shipped 12 tons of sphalerite and 6 tons of zinc carbonate in 1915. The shipments from Boone County were 6 tons of galena concentrates, 140 tons of sphalerite,

and 1,030 tons of zinc carbonate; those from Newton County were 68 tons of galena, 13 tons of sphalerite, and 369 tons of zinc carbonate. Mines in Searcy County shipped 6 tons of sphalerite and 225 tons of zinc carbonate. Shipments of concentrates from Marion County were much larger than those from all other Arkansas counties combined, and amounted to 5 tons of galena, 435 tons of sphalerite, and 6,276 tons of zinc carbonate.

REVIEW BY DISTRICTS.

Baxter County.—Several of the old mines and prospects on Pigeon Creek, Jenkins Creek, the north fork of White River, and Bald Dave Mountain were reopened, but the only shipment made in 1915 was a small quantity of free zinc carbonate ore from the Beane mine, in sec. 22, T. 21, R. 12 W. The lease on this property and also on the Michigan mine, in sec. 1, T. 18, R. 14 W., was taken by J. Conness Shepherd late in the year and considerable development was done on both leaseholds.

Izard, Lawrence, and Sharp counties.—The production in 1915 from these counties, which are in the most easterly part of the northern Arkansas region, consisted of small shipments of sphalerite and zinc carbonate from the Hoppe mine and the Mollie L. mine, near Black Rock, in Lawrence County. The Hoppe is one of the mines formerly owned by the American Zinc Co., from which ore was shipped in 1871 and 1872. This mine, which is in the NE. ¼ sec. 19, T. 16 N., R. 2 W., was operated by the Lavender Mining & Milling Co., which also acquired the old Calamine tract of 1,000 acres in T. 16 N., R. 4 W., and the Pearce mine in sec. 10, T. 15 N., R. 4 W., in Sharp County. These mines have been idle since 1900, at which time a 113-foot shaft was sunk at the Pearce mine. This shaft has been reopened and sphalerite ore mined from drifts at the 50-foot level. The mine was equipped with a concentrating plant of 50 tons capacity, but no shipments of ore were made in 1915. The Mollie L. mine, which is in sec. 18, T. 18 N., R. 2 W., produced sphalerite and zinc carbonate concentrates. The mine is operated by means of an open cut and a 20-foot shaft and is equipped with a crusher, rolls, and hand jigs. There was no mining done at the old Lincoln mine in Black Rock district, which is equipped with a 100-ton mill. Preparations were made to resume work in 1916 by repairing the mill and surface equipment. The Pine Ridge Mining Co. were developing sulphide ore bodies on the Gibson land in the Black Rock district by drilling and open cuts.

Boone County.—The producing districts in Boone County were Zinc, Sugar Orchard, and Lead Hill, and the two first-named districts are partly in Marion County. The town of Zinc, which is the shipping station for the surrounding districts, has grown rapidly on account of the active prospecting and working of the carbonate prospects and mines in its vicinity. Carbonate ores were mined and sold by many small operators, but the mining and milling of sulphide ores was spasmodic and the shipments of sphalerite concentrates in 1915 were much less than was expected. The Jack Pot mine, owned by the Earl Mining & Smelting Co., which is equipped with a 150-ton mill, was worked during the first part of 1915. It was the largest producer of sphalerite concentrates in Boone County. The mills at the Broome

County and Iola mines were each operated for a brief period, during which some high-grade sphalerite was shipped. Both of these mines are in Marion County, near the Boone County line. New lessees have taken over both of these well-equipped properties, and it is expected that they will be more actively operated. The largest reported shipments of zinc carbonate concentrates were from the Almy land. Part of the output came from various lessees who shipped lump ore and the remainder was milled carbonate concentrates produced at the 50-ton mill owned by W. H. Almy. The Coon Hollow mines of the Lead Hill Mining & Smelting Co. were worked by T. R. Cantrell, L. L. Brown, E. Barham, C. E. Lewis, and other lessees, who shipped a large quantity of high-grade zinc carbonate. The surface equipment at the Madison mine was improved. The shaft was sunk deeper and crosscuts were run connecting both tunnels. The production of milled carbonate concentrates in the 60-ton plant was quite large during November and December, 1915. Part of the production was that of W. W. Doolin, obtained from the lease on part of the Madison fee. The Westrich and the Barham leases on the Manchester-Rhodes land, northwest of Zinc, were amongst the most profitable in the district. There were a few shippers of small quantities of galena and of sphalerite and many operators who mined and sold some zinc carbonate. Amongst these producers were Walker & Meaney, Sandstead & Stackhouse, J. M. Burris, and P. M. Headley. Many small lots of ore were purchased by L. L. Brown and held until the concentrates could be shipped in carload lots. In the vicinity of Zinc there are large dumps of waste taken out in mining lump carbonate. A custom mill having a capacity of 50 tons was built and operated by T. Thomas in December, 1915, which will recover the zinc carbonate from the old tailings and also handle the fine dirt as fast as taken out by the miners, in Sugar Orchard camp. The mines in the vicinity of Zinc have the advantage of fairly good roads and a short haul to the railway, and it is probable that the production in 1916 will be much larger than it was in 1915.

Newton County.—From mines in the Mount Hersey and Yardell districts in the eastern part, and the Ponca district in the western part of Newton County, were shipped 68 tons of lead concentrates, 13 tons of sphalerite, and 369 tons of zinc carbonate. The J. R. Underwood & Co. lease on Granby Mining & Smelting Co.'s land was the sole producer of lead and zinc ores from the Mount Hersey district in 1915. The Speer mine in sec. 9, T. 16 N., R. 19 W., controlled by John T. Fuller, was the one producer in the Yardell district. Only small quantities of sphalerite and zinc carbonate were shipped from the Speer, as milling operations were hampered by lack of water during the fall months. The old 100-ton mill was rebuilt and other improvements were made. The main shaft is 140 feet deep and the air shaft 80 feet. The sulphide ore mined in 1915 came from the 80-foot level and the carbonate ore from open-cut workings less than 20 feet deep. Nearly all the galena concentrates shipped from Arkansas in 1915 came from the Isaac Kilgore lease, on the Thomas Baker land, near Ponca. About 75 per cent of the zinc carbonate credited to Newton County in 1915 was derived from mines in the same district. E. R. Springer, who operated the old Spanish-Lemarr, Jack Pot, and Blue Bluff mines, was the largest shipper of zinc concentrates

in 1915. The Keys mine, which produced some lump zinc carbonate, was transferred to new owners late in 1915, who intend to erect a mill. The Giersa & Bennett land was leased to the Eleventh Hour Mining Co. in October and several carloads of zinc carbonate were sold in 1915. The new lessees intend to develop the 120-acre lease by company operations and also by subleasing portions of the tract.

Searcy County.—The mines in Searcy County produced 6 tons of sphalerite and 225 tons of zinc carbonate and silicate concentrates in 1915. This output came from the Evening Star, Myers Hollow, and Massingale mines in Water Creek district; the North Star and Maumee mines, in Maumee district; the Lockhart and Excelsior mines in St. Joe district; and the Big Hurricane in Pindall district. A 40-ton concentrating plant was erected by the Evening Star Mining Co. at its property situated in sec. 10, T. 16 N., R. 15 W., and the production of this small mill was the largest made by any mine in Searcy County. The Massingale mine, owned by the Silver Run Mining Co., is in sec. 6, T. 16 N., R. 15 W. The ore shipped was taken out during prospect work as the new 100-ton concentrating plant was not completed in 1915. The Myers Hollow mine is on the S. A. Lay lease of the Lone Star Zinc & Copper Mining Co.'s land and the free carbonate ore shipped in 1915 was recovered during the driving of a 110-foot tunnel. A considerable quantity of ore was placed on the dump to be treated when a concentrating plant is built. The old Maumee mine was leased to the Maumee-Joplin Mining Co. late in 1915 and the ore shipped was hand-cobbed carbonate. The 150-ton mill on the land was being rebuilt and equipped. The North Star mine was operated by George Cantrell, who shipped a small quantity of carbonate ore. The Jack Pot and Churchill mines were being developed and arrangements were made for a concentrating plant at the Jack Pot. The Big Hurricane mine in sec. 6, T. 16 N., R. 18 W., near Pindall, was leased by J. Conness Shepherd. The disseminated zinc carbonate ore body is mined by means of open cuts and milled in a 100-ton plant, which was completed early in 1916. The mill and tailing plant are now producing about 100 tons of concentrates a month. Small shipments of lump carbonate were made from the Lockhart and Excelsior mines in the St. Joe district. The Ward mine, in sec. 18, T. 16 N., R. 17 W., was being developed by D. H. Morgan. Two shafts were sunk and surface equipment was installed. No free ore was shipped, but a 15-foot face of high-grade sulphide ore is said to have been opened at the 60-foot level. A 200-ton concentrating plant is to be built.

Marion County.—About 50 mines in Rush, Dodd City, Kingdon Springs, Buffalo, Yellville, and other districts, produced zinc or lead concentrates in 1915. The total output of mines in Marion County in 1915 was 5 tons of galena, 435 tons of sphalerite, and 6,276 tons of zinc carbonate and silicate.

The producing mines in the vicinity of Dodd City were the Cochran, Columbia, Compound, Durham, Jones & Miller, Edna Bee, Governor Eagle, Hampden & Rowden, Lost Dollar, Stillwell, Markle, North Star, Pilot Rock, Copperhead, Rising Sun, Tar Kiln, Milum, and Walters & Meaney. The largest production of sphalerite was from the treatment of the old dump at the Governor Eagle by hand jigs, and the largest shipment of zinc carbonate ore was that from the Rising

Sun mine. The McKay mine, operated by J. Stillwell, recovered both hand-cobbed sphalerite and zinc carbonate ores by means of a 60-foot shaft and tunnels. Several prospects were opened on the Durham & Campbell land, from which a car of high-grade carbonate was shipped. The Compound mine was operated by Gus Young. A steam drill was used in opening the 150-foot tunnel into the hill and lump sphalerite and zinc carbonate were shipped. The Bear Hill Mining Co. property in sec. 11, T. 19 N., R. 17 W., was developed and a 250-ton mill was contracted for. There are two shafts in ore, one of which is 125 feet in depth and the other 45 feet.

In the Kingdon Springs and George Creek districts the mines producing sphalerite concentrates were the Monkey Hill and the Beattie, both of which have shafts and are equipped with concentrating plants. Zinc carbonate or silicate was shipped in 1915 from the Full Moon, Bohler & Gram, Bardeen, Blue Flag, Silver Cap, Homestake, High Peak, and Onwatta mines. Of these mines the Onwatta, operated by W. A. McCurry, and the Blue Flag and Silver Cap, operated by W. L. Seawell, were the largest producers. C. M. Taylor did development work on the High Peak, Mary Taylor, and Kathleen mines. The work accomplished was preliminary to more active operations and the only shipment was that of a few tons of lump zinc carbonate. There were shipments of lump carbonate from a few mines near Yellville, including the Avey, Reynolds, Lone Pine, Glen Addie, Phillips, and Willett. The Reynolds or Blue John mine is equipped with a concentrating plant and is leased to E. B. Griswold. The Willett mine, situated in sec. 13, T. 18 N., R. 16 W., was operated by A. F. S. Cooper, who was the largest shipper of ores in the Yellville district.

One of the most prominent producers of zinc carbonate ore in Arkansas in 1915 was the Sure Pop mine in sec. 34, T. 17 N., R. 16 W. This mine, which is owned by J. Conness Shepherd, is equipped with a 100-ton concentrating plant, which was completed in April, 1915, and was operated steadily after that date until the end of 1915. Many mines and prospects were developed in the Buffalo River and Warner Creek districts, and shipments of sphalerite concentrates were made from the Bonanza and Dixie Girl mines and of zinc carbonate from the Cave Springs, Dixie Girl, Ground Hog, and Monarch mines. The Bonanza property, in sec. 10, T. 17 N., R. 14 W., which is equipped with a concentrating plant, was leased to J. W. Kesterson, who milled a quantity of ore taken out from two shafts. It is stated that good bodies of ore were blocked out in the Ground Hog and Mine 16 mines, by W. T. Barr, who shipped some lump ore taken out during development. The output from the Dixie Girl mine was small, but zinc carbonate ore was developed by means of an open cut and sphalerite was found in tunnels driven in the hill. A sawmill was built, 3 miles of wagon road were constructed, and the erection of a 150-ton mill started, which will be ready for operation in May, 1916. The Chickasaw, Fox Den, Lion Hill, George Washington, Sam Hill, and other mines were being prospected and developed.

Rush district.—The Rush district produced about 50 per cent of all the zinc concentrates shipped from Arkansas in 1915, although the number of mines operated was less than in some other camps. The only output of sphalerite was that of the Silver Hollow mine, but that

of zinc carbonate amounted to more than 4,200 tons, the larger part of which was milled concentrates produced at the Morning Star, Philadelphia, Red Cloud, McIntosh, and Leader mines. The largest shipment of lump carbonate was from the Yellow Rose mine, with smaller shipments from the White Eagle, Carbonate Point, Omeara, Edith, Harsha, Monte Cristo, and Silver Hollow mines.

The Morning Star Mining Co. has a concentrating plant of 100 tons capacity, in which is milled ore obtained by means of tunnels and open cuts in the adjoining Smuggler, Morning Star, Ben Carney, and Capps mines. The Capps mine was opened about August and a long tramway was erected to send the ore to the mill.

The largest producing properties in the district were those of J. Conness Shepherd, who operated the Philadelphia, McIntosh, and Leader mines. The Philadelphia mine is developed by means of four tunnels, and the 100-ton concentrating plant, which was equipped with tables, was operated steadily. The McIntosh and Leader mines are also opened by tunnels and the ore is treated at the McIntosh mill, which was entirely remodeled and rebuilt so as to make it one of the most efficient in the State. The Red Cloud mine, which is on the hillside, 90 feet above the banks of Buffalo River, was leased to the Gertrude Mining Co. in 1915. The 150-ton mill at the mine made a large output of high-grade zinc carbonate concentrates in 1915. It is stated that the property has been leased to J. Conness Shepherd in 1916 and that the former operators have opened a new mine east of the Red Cloud upon which a mill is to be built. The 100-ton mill of the Consolidated Silver Hollow Mining Co., situated on Buffalo River, was in operation part of the year. Some carbonate ore was extracted from a tunnel in the upper run of ore. The sulphide ore is taken from a tunnel which is now 800 feet in the hill and which at the face of the ore now being mined is about 20 feet below the water level of Buffalo River and about 400 feet lower than the summit of the hill. The Yellow Rose mine, which is on the east side of Buffalo River, near its junction with Rush Creek, was leased by J. L. McCarthy. High-grade, hand-cobbed ore was shipped and a large quantity of "mill dirt" was mined, which is now being treated in a 100-ton concentrating plant built in 1916. The Carbonate Point and Omeara mines were opened by means of open cuts and tunnels and the operators, Teagarden Bros. & Point, shipped a good quantity of carbonate ore. The White Eagle mine on the Buffalo Zinc & Copper Co.'s land was leased to Seawell Bros., who sold hand-cobbed carbonate and also accumulated a pile of mill rock for a 100-ton concentrating plant now being erected. The Edith mine, which is also on the Buffalo Zinc & Copper Co. land, had a small output and has since been equipped with a mill. The Harsha mine was leased to the Southern Mining Co. and had only a nominal output.

ILLINOIS.

By J. P. Dunlop.

PRODUCTION.

In the chapter entitled "Silver, copper, lead, and zinc in the Central States" of Mineral Resources for 1914 was given a historical review and bibliography of the literature relating to the mining of

lead and zinc in the northern and southern districts of the State of Illinois. Estimates were also given of the total quantity of concentrates and metal produced to the end of 1914.

Mine production of lead and zinc in Illinois in 1915.[a]

District.	Ores.							
	Lead concentrates (galena).		Zinc concentrates.		Metal content.			
			Sphalerite.		Lead.		Zinc.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Northern Illinois	679	$32,093	20,454	$751,277	495	$46,530	5,534	$1,372,432
Southern Illinois	641	27,851	.....	.....	459	43,146	.....	.....
Total, 1914	1,320	59,944	20,454	751,277	954	89,676	5,534	1,372,432
	954	41,094	16,725	320,012	717	55,926	4,811	490,722

[a] In calculating the metal content of the ores from assays allowance has been made for smelting losses in the case of zinc but not in the case of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily quotations at New York and that of zinc from the average sales price reported by the smelters.

Mine production of silver in southern Illinois, 1907–1915.

	Silver.		Lead concentrates, silver bearing.	
	Quantity (fine ounces).	Value.	Quantity (short tons).	Ounces of silver per ton.
1907	2,852	$1,882	497	5.74
1908	2,051	1,087	359	5.71
1909	1,011	526	259	3.90
1910	2,022	1,092	398	5.08
1911	3,036	1,609	482	6.25
1912	4,731	2,909	748	6.31
1913	3,541	2,139	507	7.00
1914	2,112	1,168	308	6.86
1915	3,864	1,959	641	6.03

Tenor of lead and zinc ore and concentrates produced in Illinois, 1914 and 1915.

	1914	1915
NORTHERN ILLINOIS.		
Total crude ore, short tons	261,300	316,000
Total concentrates in crude ore:		
Lead, per cent	0.25	0.22
Zinc, do	6.4	6.5
Metal content of crude ore:		
Lead, do	.19	.17
Zinc, do	2.3	2.18
Average lead content of galena concentrates, do	76.2	72.9
Average zinc content of sphalerite concentrates, do	36.5	33.5
Average value per ton:		
Galena concentrates	$44.70	$47.27
Sphalerite concentrates	$19.13	$36.73
SOUTHERN ILLINOIS.		
Average lead content of galena concentrates, per cent	73.5	71.6
Average value per ton of galena concentrates	$39.99	$43.45

The lead concentrates produced in southern Illinois are recovered in concentrating the fluorspar. To speak of the total crude ore raised as crude lead ore would be misleading. No attempt has been made, therefore, at calculating the quantity or the tenor of the crude ore.

The value of the mine production of silver, lead, and zinc in Illinois in 1915 was $1,464,067, as compared with $547,816 in 1914. The lead concentrate produced amounted to 1,320 short tons, which was 366 tons more than in 1914, and the recoverable lead content increased from 717 tons in 1914 to 954 tons in 1915.

The output of sphalerite concentrate increased from 16,725 tons in 1914 to 20,454 tons in 1915, the recoverable zinc content of the concentrates increased from 4,811 tons in 1914 to 5,534 tons in 1915, and the value was $431,265 more in 1915 than in 1914.

The silver recovered from lead concentrates amounted to 3,864 fine ounces, valued at $1,959, against 2,112 fine ounces, valued at $1,168, in 1914.

The lead and zinc deposits of Illinois fall into two distinct regions marked by different mineral association and structural environment. Those of southern Illinois belong to the Kentucky-Illinois fluorspar district; those of northern Illinois belong to the upper Mississippi Valley region.

NORTHERN ILLINOIS.

The lead and zinc mines of northern Illinois are all in Jo Daviess County, the extreme northwest county of the State. The ores have the same structural relations as in the upper Mississippi district generally; that is, they occur disseminated through the limestone, or in openings in it called "crevices," "pitches," or "flats," depending on their attitude to the horizontal. These openings have, in general, an east and west trend, known as their "range." The ore bodies are sometimes continuous for long distances along these "ranges," which for that reason largely control the prospecting, both by shafts and by drilling. The ore deposits occur in the Galena dolomite and in the upper part of the Platteville limestone, both of Ordovician age.

The ores are galena, smithsonite, and sphalerite, though the two latter are much less common now than formerly, when the deposits worked were mostly shallow and above water level. In early years the galena ores only were mined and the ore was taken from shallow pockets in quantities ranging from a few tons to several thousand.

Although the lead output of northern Illinois, Wisconsin, and Iowa has been large in the past and the ores have been smelted near the mines,[1] the output in recent years has been comparatively small and no ores have been smelted in those States.[2] The galena is practically nonargentiferous, and the zinc ores are not known to contain cadmium. Iron pyrites is very commonly associated with the ores, frequently in such quantity as to necessitate roasting and magnetic separation.

The Pittsburg is the only mine at which a roasting and separating plant was used in connection with the concentrating plant. There

[1] Cox, G. H., Lead and zinc deposits of northwestern Illinois: Illinois Geol. Survey Bull. 21, p. 14, 1914.
[2] Pulsifer, H. B., History of lead smelting in Wisconsin: Min and Eng. World, May 2, 1914, p. 821.

are, however, two such roasters at Galena, one of which is operated by the Wisconsin Zinc Co. and the other by the Galena Refining Co., and in the adjoining districts in Wisconsin there are plants at Cuba City, Benton, Platteville, Linden, and Mineral Point.

As none of the operators in the Sand Prairie district or in the Elizabeth district reported any production in 1915 the entire output of northern Illinois is included under the Galena district. The production of lead concentrates was 679 tons, valued at $32,093, as compared with 646 tons, valued at $28,778, in 1914.

There were 20,454 tons of sphalerite concentrates, valued at $751,277, produced in 1915, an increase of 3,729 tons in quantity and of $431,265 in value. The average price per ton received for sphalerite concentrates nearly doubled.

The tonnage of crude ore mined increased from 261,000 tons in 1914 to 316,000 tons in 1915. The average recovery of zinc concentrates from the ore milled was about the same as in 1914, and the percentage of lead was slightly less than in 1914.

The average zinc content of the sphalerite concentrate decreased from 36.5 per cent in 1914 to 33.5 per cent in 1915.

Galena district.—The Galena district includes the mines in the vicinity of Fever River from Mississippi River to the Wisconsin State line. For many years the principal production was of lead ores, but in recent years the output of zinc has increased to such an extent that the lead is of minor importance. In 1907 the yield of zinc concentrates amounted to only 2,530 tons; in 1915 the output was 20,454 tons, exceeding that of 1912 by more than 6,700 tons.

The largest production of lead and zinc concentrates in northern Illinois in 1915, as in 1914, was derived from the old Marsden-Black Jack mine of the Mineral Point Zinc Co. The mill was steadily operated during 1915 on dirt obtained by means of two shafts, one of which is 200 feet and the other 250 feet deep. The mill has a capacity of 600 tons in 24 hours, and is driven by electric power. The mine is equipped with a steel head frame and a double-compartment mill shaft and the ore is hoisted in skips. The production of the mine would have been considerably larger if there had not been at times some difficulty in obtaining adequate power from the Interstate Light & Power Co. The second largest producing mine was the Pittsburg, operated by the Great Western Lead Manufacturing Co., which owns a 150-ton concentrating plant on land adjoining the Marsden-Black Jack. The shaft at this mine is 152 feet deep. A roasting and separating plant, having a capacity of 30 tons a day, was erected in 1915.

The North Western mine on the Stacey land, which has a 100-foot shaft and a concentrating plant, was in operation until May. The mine may be reopened in 1916. J. L. Nelson reported the shipment of some lead and zinc concentrates from the Vinegar Hill lease of the Stacey land. The output of the North Unity mine of the Vinegar Hill Zinc Co., on the Curran land, was the third largest in Illinois. The shaft at this mine is 175 feet deep and the mill has a capacity of 20 tons per hour. Thirteen holes were drilled on the Hughlett & Gray land by the Vinegar Hill Zinc Co., and the lease will be mined in 1916. The Graham land at Days Siding was also leased by this company, and 36 holes were drilled, a shaft sunk, and the erection of a 200-ton concentrating plant commenced. Some lead concentrates were

shipped from the Josephine mine on the Doolin land, but no lead ore was taken out at the Easy Hit mine, belonging to Gus Brown. The Birbeck mine at Days Siding was under development by the Wisconsin Zinc Co. A 190-foot shaft was sunk and a 200-ton mill built, which is in operation in 1916. The Joplin Separating Co.'s property at Galena, which was destroyed by fire in 1910, was purchased by the Wisconsin Zinc Co. The new owner completely rebuilt the plant and increased the capacity. A considerable part of the green ore derived from the various mines of the Wisconsin Zinc Co. is now treated at this plant, from which the roasted concentrates, carrying about 60 per cent zinc content, are sent to the smelters.

SOUTHERN ILLINOIS.

The lead and zinc deposits of southern Illinois are found in Pope and Hardin counties in rocks of Mississippian age in the northern extension of the Kentucky-Illinois fluorspar district.

The principal product of the mines in recent years has been fluorspar, and the yield of galena is small compared with the output from other districts in the Central States. The total production of galena concentrates for southern Illinois, 1906 to 1915, inclusive, has been 4,678 tons, most of which has been shipped from the Fairview and Rosiclare mines. The shipments of zinc ores from the district have been comparatively small and scattered. The only recorded shipments of zinc carbonate were made from the Empire mine in 1903 or 1904, and in 1906 four companies made shipments aggregating 103 tons.

The structural relations and the mineralogic association are similar to those of the deposits of western Kentucky and in striking contrast to those of the deposits of northern Illinois. The ores occur in fissure veins, in association with jointing and faulting. The mines have been worked to depths of 300 and 500 feet without disclosing any decrease in the dimensions of the ore bodies. Dikes and sheets of lamprophyre and dikes of mica peridotite occur in the vicinity, but not in direct connection with the ore deposits. Galena is the most important metallic mineral. Formerly, and nearer the surface, large bodies of galena were worked, but it is at present produced incidentally in the concentration of the fluorspar. For this reason it would be misleading to give the quantity of crude ore. As the district is not reached by railway, the product of the mines is dependent on river transportation.

The galena of southern Illinois is notably argentiferous as compared with the rest of the Mississippi Valley ores, the silver content ranging up to 12 and 14 fine ounces per ton of lead concentrates and averaging for the last five years from 4 to 7 fine ounces per ton of lead concentrates. Sphalerite, or zinc blende, is the next important metallic mineral, but it occurs much less plentifully than galena. It is recovered as zinc middlings in the concentration of the fluorspar. The difficulty of making a clean separation of the zinc middlings has kept down the production of zinc. None has been sold from southern Illinois in the last seven years. The principal vein minerals are fluorspar, calcite, and barite.

The shipments of galena concentrates increased 333 tons in quantity, and the silver content recovered in treating the concentrates increased from 2,112 ounces in 1914 to 3,864 ounces in 1915. The

average lead content of the concentrates decreased from 73.5 per cent in 1914 to 71.6 per cent in 1915. The average silver content per ton recovered from lead concentrates decreased from 6.86 ounces in 1914 to 6.03 ounces in 1915.

The Fairview Fluorspar & Lead Co. operates on the Good Hope vein, which was first developed in 1862. Nearly all the ore mined in 1915 was hoisted through the Blue Diggings shaft. Seventy per cent of the ore came from the 400-foot level and most of the remainder from the 200-foot level. The ore mined at the 400-foot level was of higher grade than that at the 300-foot level, and the shaft is being sunk to the 500-foot level. A new shaft 200 feet in depth was sunk on what the operators consider the southern extension of the Good Hope vein, and development work done showed the ore body to resemble the Good Hope in general character.

The Rosiclare Lead & Fluorspar Co., which is the largest producer of fluorspar and lead concentrates in southern Illinois, operates on an ore body which is probably continuous with that of the Fairview. The main shaft at the Rosiclare has reached a depth of more than 500 feet, and the mine has a long record of continuous production. The steel and concrete mill, entirely fireproof, is designed to handle 500 tons a day, and is provided with special facilities for saving the lead and zinc both by jigs and by tables. The lead recovered is stated to be about 0.8 per cent of the quantity of ore treated and the quantity of blende is practically negligible.

IOWA.

By J. P. Dunlop.

The lead and zinc deposits of Iowa extend along Mississippi River for nearly 80 miles, in Dubuque, Clayton, and Allamakee counties. They are found in the galena dolomite, of Ordovician age.

In early days the Dubuque mines were the most important source of lead in the United States, and in later years the mines, especially those in the vicinity of Durango, yielded considerable quantities of zinc-carbonate ore. Nearly all this earlier mining was done above water level, and only within the last few years has there been much attempt to mine below water level. Therefore the production, particularly of zinc-blende ore, for these years, though small, is noteworthy, since it represents the attempt to mine at deeper levels.

The ore deposits of the Dubuque district occur in crevices and in caves or "openings" along these crevices. Of these openings there are five or six, the "top," "middle," and "third" being the most prolific of ore. The "flats" and "pitches" common in the Wisconsin mines have been found in only one or two places in Iowa. The crevices have an east-west trend and sometimes extend considerable distances, being mined at different places, in which case they are known as "ranges." The mining operations of recent years have generally been confined to attempts to find paying ore at deeper levels in these old ranges, which are known to have yielded ore in former days in the upper openings.

There was no production of either lead or zinc reported by Iowa mines in 1914 or in 1915. Most of the mining companies have ceased work and forfeited their charters. Some lead will probably continue to come from the small mines, but the present outlook is not favorable for any large yield of zinc.

KANSAS.

By J. P. Dunlop.

PRODUCTION.

Production of lead and zinc in Kansas, 1915.[a]

District.	Ores.					
	Lead concentrates.		Zinc concentrates.			
	Galena.		Sphalerite.		Carbonate and silicate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Galena and Badger Peacock	1,581	$83,083	22,128	$1,499,526	71	$2,522
Lawton	37	2,332	5,625	424,445		
State total: 1915	1,618	85,415	27,753	1,923,971	71	2,522
1914	1,808	79,976	21,812	830,176	38	623

District.	Metal content.			
	Lead.		Zinc.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Galena and Badger Peacock	1,183	$111,202	11,352	$2,815,296
Lawton	29	2,726	3,013	747,224
State total: 1915	1,212	113,928	14,365	3,562,520
1914	1,409	109,902	11,284	1,150,968

[a] In calculating the metal content of the ores from assays, allowance has been made for smelting losses in the case of zinc but not in the case of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, while the value of the lead is calculated from the average daily quotations at New York and that of zinc in 1915 from the average sales prices reported by the smelters.

Tenor of lead and zinc ore and concentrates produced in Kansas, 1914 and 1915.

		1914	1915
Total crude ore	short tons	540,500	709,400
Total concentrates in crude ore:			
Lead	per cent	0.33	0.23
Zinc	do	4.04	3.92
Metal content of crude ore:			
Lead	do	.26	.17
Zinc	do	2.32	2.25
Average lead content of galena concentrates	do	77.9	74.9
Average zinc content of sphalerite concentrates	do	57.4	57.4
Average zinc content of zinc silicate and carbonate	do	34.2	38.0
Average value per ton:			
Galena concentrates		$42.02	$52.79
Sphalerite concentrates		$38.06	$68.96
Zinc silicate and carbonate		$16.40	$35.52

The lead and zinc deposits of Kansas, so far as developed, are limited to the southeastern portion of the State, in Cherokee County. They comprise the western extension of the ore deposits of the Joplin

region and display the general characteristics of that area, except that here typical sheet-ground deposits have not been extensively developed. The ores are galena and lead carbonate, sphalerite or zinc blende, and zinc carbonate and silicate. The galena is practically nonargentiferous, carrying but a small fraction of an ounce of silver to the ton of lead concentrates.

It is difficult to obtain the production for early years or to segregate the Kansas ores from those produced in the adjoining portion of the Joplin region in Missouri. If to the figures obtained and published by the State Geological Survey of Kansas for the years 1886–1903[1] are added those for the years 1904–1915, published by the United States Geological Survey, a total output of 1,021,178 tons of zinc concentrates and of 147,222 tons of lead concentrates are shown as the approximate output of Kansas for the years 1886–1915, inclusive.

The value of the mine production of lead and zinc in Kansas in 1915 was $3,676,448, against $1,260,870 in 1914. Nearly all the increase was caused by the larger quantity and increased average price of zinc contained in the sphalerite concentrates shipped.

The value of the recoverable lead in galena concentrates shipped from Kansas mines in 1915 was $4,026 more than in 1914. The production of lead concentrates declined from 1,808 tons in 1914 to 1,618 tons in 1915, and the metal content from 1,409 tons to 1,212 tons. The percentage of lead concentrates in crude ore milled decreased from 0.33 per cent in 1914 to 0.23 per cent in 1915. This decrease was partly due to the lessened quantity of ore from the "blanket ground" mined in 1915, though it is shown by the production tables that the percentage of lead in ore mined and treated has steadily declined for several years.

The average lead content of the galena concentrates sold was 3 per cent less in 1915 than in 1914, but the average price received for such concentrates was $52.79 a ton, against $42.02 in 1914.

The production of zinc carbonate and silicate was 71 tons, valued at $2,522, which was 33 tons more than in 1914.

The production of sphalerite concentrates in 1915 was 27,753 tons, valued at $1,923,971, the largest quantity since 1908, and an increase of 5,942 tons in quantity and of $1,093,795 in value, as compared with 1914. Notwithstanding that less "sheet ground" ore was mined, the proportion of sphalerite concentrates recovered from crude ore milled declined from 4.04 per cent in 1914 to 3.92 per cent in 1915. This decline was the natural tendency to mine lower-grade ores made profitable by the increase in the average selling price of sphalerite concentrates from $38.06 in 1914 to $68.96 in 1915. The average zinc content of the sphalerite concentrates shipped was the same in 1915 as in 1914.

The increase in the output of zinc ore was entirely that of the Galena district, for no mining was done at Badger-Peacock. The output from Lawton district was less in 1915 than in 1914, although the Eastern mine had a larger yield than in any previous year. There were not many changes in the ownership of mining lands at Galena nor were there many new operators that had a large production. The increased yield was chiefly that of the much larger number of

[1] Haworth, Erasmus, and others, History, geography, geology, and metallurgy of Galena-Joplin lead and zinc: Kansas University Geol. Survey, vol. 8, 1904.

small mines opened. The "dirt" or ore from these mines was sold in the rough or treated at custom mills, which were operated double shift to handle the ore. If the summer of 1915 had not been an unusually wet one, the production of Kansas would have been several thousand tons larger.

REVIEW BY DISTRICTS.

Badger-Peacock district.—The underground workings of the old mines, which have produced large quantities of sphalerite, have been flooded since the spring of 1912. It was reported several times during 1915 that the dike along Spring River was to be rebuilt and the mines pumped out, but no actual work was accomplished. The only shipment from the Badger-Peacock district in 1915 was a small quantity of sphalerite recovered from tailings at the 75-ton mill belonging to C. W. Theurer.

Lawton district.—The Lawton district, which is situated 3½ miles north of Badger-Peacock, produced less sphalerite in 1915 than it did in 1914. The decline was not due to lessened activity in the district, for drilling was done on a large area of land adjoining the original producing properties and the village of Lawton increased rapidly in population. The output of the Eastern mine was more than in previous years, but the caving of the mine workings at the H. L. & S. mine and delays occasioned by the excessive quantity of water at the Hall mine reduced the yield of those mines.

About 135,000 tons of ore and tailings were milled in 1915 and the shipments made were 37 tons of galena, valued at $2,332, and 5,625 tons of sphalerite concentrates, valued at $424,445. The dirt milled at the Eastern mine averaged nearly 5 per cent in concentrates and the zinc content of the sphalerite was about 60 per cent. The grade of the concentrates made at the other producing mines was lower than that of the Eastern.

The mine of the Eastern Lead & Zinc Co. is one of the largest in the Joplin region. The plant is complete, the mine is efficiently worked, and development work is systematically done. The ore reserves are large, insuring a steady production for many years. The 200-ton mill is located on the Robinson lease, and electric power is used to drive the mill and for pumping. Two shafts were used regularly to hoist ore, which was mainly derived from the 150-foot level, and two other shafts were utilized in opening new ground. The Della A. and H. L. & S. mines are on land lying north of the Robinson land and owned in fee by the Eastern Lead & Zinc Co. Both of these mines were operated in the first half of 1915. The workings at the H. L. & S. mine caved in and destroyed the 150-ton mill. The property will be operated by the landowners when the drifts now being cut from the Eastern mine reach those of the H. L. & S. mine.

A new tailing mill of 200 tons capacity was built by Crane & Co. in October, which is used to re-treat the tailings from the Eastern mine. Electric power is used in this plant, which is equipped with five tables.

The producing leases on the S. D. Ball land were those of the John A. Hall Mining Co. and the Greenfield & Lockwood Mining Co., though considerable drilling was done by the landowner, which is said to have indicated other bodies of ore. The Hall mill of 150 tons

was run intermittently and the output was not as large as expected. The Greenfield & Lockwood Mining Co. sunk a 175-foot shaft and erected a completely equipped electrically driven mill of 300 tons capacity. The mine was not sufficiently developed in 1915 to furnish the mill a steady supply of ore, and the small production of concentrates was mainly recovered from the low-grade dirt on the dump.

Galena district.—The production given for the Galena district in 1915 includes the small shipments from the Badger-Peacock district and also those from the Joplin-Columbus and Buckeye mines, in sec. 12, T. 34 S., R. 25 E., and the Shawnee mine, in sec. 23, T. 33 S., R. 25 E. The output of the Joplin Royalty Mining Co. is also included with that of Galena. This mine is in sec. 15, T. 28 S., R. 34 E., the shafts and concentrating plant are in Kansas, and the ore treated in 1915 was taken from drifts across the State line in Missouri.

The production of lead concentrates in the Galena district in 1915 was 1,581 tons, valued at $83,083, as compared with 1,704 tons, valued at $75,376, in 1914. The shipments of zinc concentrates (all of which was sphalerite except 71 tons) were 22,199 tons, an increase of 7,096 tons. Owing to the higher prices paid for zinc concentrates and the increased shipments in 1915, the total value of the zinc concentrates was $934,252 more than it was in 1914. There was an increase of 33 tons in the quantity of zinc carbonate and silicate, and there were no sales of lead carbonate in 1915. The metal content of the lead concentrates was 1,183 tons in 1915, against 1,327 tons in 1914.

The increased output of sphalerite concentrates was almost entirely due to the more numerous small mines operated on leased lands. Most of these leases were not equipped with concentrating plants and the "dirt" was sold in the rough or hauled to a custom mill for treatment. Many of the large mines showed a smaller output in 1915 than in 1914. The production from the Hartford, Clermont, and Diplomat mines declined and the yield from leases on the South Side, Murphy, New Century, Illinois, Windsor, and Wyandotte lands increased. The shipments from the Portia Mining Co. and from the Empire Mining Co. were much larger than in 1914. The unusually wet weather in the summer months seriously delayed development work, restricted the mine production, and caused heavy damage to mining properties. The flume in Short Creek was partly destroyed and mine workings adjacent thereto were filled with débris.

The Joplin-Columbus mine, on the Phœbus land, and the Buckeye mine adjoining shipped sphalerite concentrates having a zinc content of 62 to 64 per cent. The Buckeye is equipped with a 100-ton mill; hand jigs were used at the Joplin-Columbus. The ore occurs as pebble "jack" at a depth of about 120 feet in very soft ground and does not require the use of crushing machinery before jigging.

The Shawnee mine, on the Hubbard land, produced ore from the 90 and 120 foot levels by means of two shafts, which was milled at a 100-ton concentrating plant.

The Joplin Royalty Mining Co. made a good production of high-grade sphalerite from ore taken from drifts in the Missouri part of the mine at a depth of about 72 feet. The ore was hoisted through a shaft located on the Kansas side of the State line.

The lessees on the South Side tract of the Playter Mining Co. reported the largest production of sphalerite concentrates in the

district in 1915, as well as a good output of lead and a small quantity of zinc silicate. There are two mills on the land, one of 80 tons capacity and the other of 200 tons capacity. Much of the concentrates came from ore mined below old workings at the shallow levels. Development by means of shafts sunk to the depth of 150 and 180 feet disclosed good bodies of ore at these levels, which should result in increased activity on the land.

The Diplomat mine on Galena Lead & Zinc Co. land was the largest producer of lead concentrates and one of the most prominent producers of sphalerite. Rough ore from other leases on the land was sold to chatters. Two mines which had a largely increased output were the Portia, on land bought from S. R. Ping by the Hurry Up Mining Co., and the Empire mine, leased by Sapp & Long. The Empire mine lies south of the Diplomat mine and part of the ore treated was from "blanket ground" lying at the 100-foot level and similar to the ore found at that level in the Diplomat. The "blanket ground" ore was extracted through the north shaft and ore from soft ground through two shafts south and west of the concentrating plant. The mill has a capacity of about 300 tons and is equipped with 5 tables. A deeper run of ore in "blanket ground" is reported to have been located by drilling. This ore body lies between 211 and 270 feet and probably will be opened by a new shaft in 1916.

Lessees of the Wyandotte Lead & Zinc Co., including Charles Manhart and the Gray Cat Mining Co., produced nearly three times the quantity of ore shipped in 1914. One 50-ton mill was in operation and a new mill having a capacity of 250 tons was built by the Wayland Mining Co. This mill was not ready for operation until 1916.

A sludge plant of 100 tons per 24 hours capacity, equipped with 6 tables, was erected by W. D. Lyerle on Bonanza Lead & Zinc Co.'s land, and the Nimmie Tam and other lessees on Bonanza land made good productions of lead and zinc.

Lessees of the Illinois Lead & Zinc Co., including the Boston Land & Mining Co., Charles Lau, Peacock-Galena Mining Co., Little Homestake Mining Co., George Playter, and their sublessees, sold considerable sphalerite concentrates and would have had a large output if their property had not been flooded with water on several occasions. The Peacock-Galena mill was run part of the time on custom ore.

The Latawanna mill operated by G. L. McCullough was one of the most important producers in the district. Part of the output was not sold in 1915.

The various interests controlled by James Murphy and W. L. Crockett, including the Empire Mining Co., Lockport Mining Co., Murphy Mining & Realty Co., and Windsor Lead & Zinc Co., made a large output of lead and zinc concentrates. Considerable loss was occasioned by the washing out of the flume on Short Creek. The flume was promptly rebuilt and the property speedily brought back to a producing basis.

The following lands and leases were actively mined and the operators sold substantial quantities of lead or zinc concentrates: W. P. Clement on the Connor land, Clermont Land & Mining Co., Scarlet Kid Mining Co. on the Glick land, Hartford Mining Co. on Empire Zinc Co.'s land, lessees of the Promoter Mining Co. on the New Cen-

tury land, Thos. Kennedy, Land & Cooley, lessees on the Luscombe & McElroy land, Merchants Mining Co., F. G. Hallam & Co. on the Cornwall land, Silver Coin Mining Co. on the Shomon & Stice land, J. A. Scott on the Templar Mining Co.'s land, Fred Stone on the Black Hills land. Other shipments were made by lessees of the J. K. Williams estate, Middle West Mining Co., Hoosier Mining Co., and L. K. Moeller.

The chatting mill belonging to J. W. Squires was run steadily all the year, and a tailing mill with an estimated capacity of 300 tons daily was being built by C. Eakhart. This mill, which was not operated in 1914, will treat the large dump at the Squires mill. It is equipped with gas engines, regrinding rolls, tables, Dorr classifier, and Dorr thickener. Concrete construction was used in part and the mill is one of the most substantial and expensive tailing plants in the Joplin region. The old chatting mill of Monlux & Co. was destroyed by fire and a modern mill was erected, which has a capacity of 100 tons. A separate sludge compartment containing six tables was also completed. The new plant was operated steadily after February 1, 1915.

KENTUCKY.

By J. P. Dunlop.

PRODUCTION.

Lead and zinc deposits are found in both central and western Kentucky. None of the mines in Franklin, Mercer, Scott, Owen, or Henry counties, in the central districts, reported any lead or zinc concentrates shipped in 1915. The mines in the fluorspar region of western Kentucky are chiefly in Crittenden, Caldwell, and Livingston counties and form a continuation of the southern Illinois lead and zinc region. The earliest available records of the occurrence of fluorspar and the associated galena in the Kentucky-Illinois region appeared in the first, second, and third volumes of the American Journal of Science, published in 1818, 1820, and 1821.[1]

The presence of zinc blende was recognized in 1854–1857 during the first geological survey of the State of Kentucky by David Duke Owen and his assistant, Sidney S. Lyon. The first lead smelter using galena from Kentucky was erected by the River Valley Mining Co. at the Royal mine [2] about 1870.

Considerable quantities of galena ores have been produced in former years, but at the present time lead is obtained solely as a by-product in the recovery and concentration of fluorspar, which is the principal economic mineral. The galena recovered is argentiferous, the silver content varying from a very small quantity to over 3 ounces a ton, but no recovery of this silver content has been reported by the smelters during the last four years. The lead concentrate shipped in any one year from Kentucky does not necessarily represent the actual recovery of lead from fluorspar mined in that year, for, being merely accessory to the fluorspar and produced in small quantities, it is frequently held until a considerable quantity has accumulated or until lead prices are high.

[1] Ulrich, E. O., and Smith, W. S. T., The lead, zinc, and fluorspar deposits of Western Kentucky: U. S. Geol. Survey Prof. Paper 36, pp. 16–17, 1905.
[2] Fohs, F. J., Fluorspar deposits of Kentucky: Kentucky Geol. Survey Bull. 9, 1907.

Production of lead and zinc in Kentucky, 1907–1915.

Year.	Ores.						Metal content.			
	Lead concentrates (galena).		Zinc concentrates.							
			Sphalerite.		Zinc carbonate.		Lead.		Zinc.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1915	370	$17,103	.....	.....	2,172	$106,079	251	$23,594	764	$189,472
1914	26	800	27	$1,120	644	12,168	16	1,248	230	23,460
1913	40	1,422	198	5,206	696	13,811	22	1,936	327	36,624
1912	151	6,827	498	25,391	750	16,006	196	9,540	491	67,758
1911	.....	.....	.....	.....	467	10,604	.....	.....	158	18,012
1910	56	1,980	.....	.....	30	300	41	3,608	6	648
1909	12	620	.....	.....	150	1,701	10	860	64	6,912
1908	.....	.....	.....	.....	.....	.....	.....	.....	.....	.....
1907	54	2,850	.....	.....	.....	.....	34	3,604	.....	.....

No shipments of sphalerite were reported in 1915 and only 27 tons in 1914, but the shipments of zinc carbonate increased from 644 tons, valued at $12,168, in 1914 to 2,172 tons, valued at $106,079, in 1915. The estimated recoverable spelter content in 1915 was 764 tons, valued at $189,472.

The shipments of galena concentrates reported in 1915 were 370 tons, valued at $17,103, compared with 26 tons, valued at $800, in 1914. The average lead content was 67.8 per cent, compared with 63 per cent in 1914. The recoverable metallic content of the galena in 1915 was 251 tons, valued at $23,594.

The total value of the lead and zinc concentrates shipped from Kentucky mines was $123,182, as against $14,088 in 1914.

The principal sellers of galena concentrates were the Roberts Fluorspar & Lead Co., the Kentucky Fluorspar Co., the Commodore Mining Co., and the Ohio Valley Fluorspar Co. Part of the galena sold by the Roberts Fluorspar Co. was purchased and the remainder was obtained from fluorspar ore mined by means of five shafts having an average depth of about 120 feet.

The zinc concentrates shipped in 1915 were entirely carbonates and were produced at the Hudson, Miller, and Tabb mines. The American Spar Co. operated the Hudson mine of the Eagle Fluorspar Co., near Salem, in Livingston County, and shipped most of the zinc carbonate. The ore was taken from an open cut and treated in a double log washer before shipment. The Miller mine, in Crittenden County, was leased to W. Murray Sanders. Five shafts were used to obtain crude ore for the log washer, which has a capacity of 25 tons. The Tabb mine of the Hoosier Mining Co., near Mexico, was operated by T. N. Fuller, who shipped zinc carbonate ore taken from shallow workings. The Pigmy mine, also located near Mexico, was under development. The Larue mine, on the Cox land, near Marion, in Crittenden County, was leased to the West Kentucky Ore Co., and a considerable quantity of low-grade sphalerite concentrates was recovered from dump ore taken out in 1914 during the sinking of the shaft to the 240-foot level. The shaft was not unwatered nor was any

of the concentrate shipped. An experimental flotation plant was built to treat the concentrates and the mill, which is of small capacity, was equipped with Isbell and Deister tables.

MICHIGAN.

By B. S. Butler.

PRODUCTION.

In 1915 the mines of Michigan produced 265,283,378 pounds of copper, valued at $46,424,591, and 585,933 fine ounces of silver, valued at $297,068, a total value in copper and silver of $46,721,659. This is an increase of $24,635,235, or about 112 per cent, in value over the production of 1914.

At the opening of the year the production of copper in Michigan, as in other districts, was somewhat below normal, though the output of the Michigan mines was not curtailed to the same extent as was that of some of the western mines. Early in the year increased demand and improved prices caused an increase in production, and from then on, under the stimulus of high prices, the mines and reduction plants were turning out copper as rapidly as possible.

The average price of copper per pound for 1915 was $0.175, and for 1914 it was $0.133. The average price of silver for 1915 was $0.507 per fine ounce, and for 1914 it was $0.553. Owing to the increase in the price of copper and to the slight increase in copper recovered per ton, there was an increase from $2.35 in 1914 to $3.76 in 1915 in the average value per ton of "rock" treated.

The smelter production, or the output of refined copper, for 1915 was 236,757,062 pounds, as compared with 158,009,748 pounds in 1914. The difference between the mine and the smelter production is due to the fact that the quantity of "mineral" produced is not the same as the quantity smelted. A company may produce either more or less "mineral" than it smelts during the year.

Value of silver and copper produced at Michigan mines in 1914 and 1915.

Year.	Silver.	Copper.		Combined silver and copper.
		Total.	Per ton of rock.	
1914	$228,665	$21,857,759	$2.35	$22,086,424
1915	297,068	46,424,591	3.76	46,721,659
Increase	68,403	24,566,832	1.41	24,635,235

The entire Michigan output of copper and silver is from the Keweenaw district. Both metals occur native in lodes remarkable for their great extent and uniformity. These lodes may be divided into two general classes—the amygdaloid, in which the metals occur together with gangue minerals, such as epidote, calcite, and zeolites, in the cellular portions of lava flows; and the conglomerate, in which the metals and gangue minerals cement and to some extent replace the pebbles forming the conglomerate. Native copper and copper minerals occur in fissures in the district, but the present output

from this type of deposit is of little importance. The "rock"[1] is of low grade and requires milling, which produces "mineral" carrying an average of about 65 per cent copper. A small quantity of "barrel" and "mass" copper is sorted at the mines and sent direct to the smelters.

In 1915 there were 12,334,700 short tons of "rock" milled, which yielded 400,178,132 pounds of "mineral" and 265,283,378 pounds of copper.[2]

The average recovery of refined copper per ton of "rock" milled in 1915 was 21.5 pounds, as compared with 17.7 pounds in 1914.

There were 585,933 ounces of silver derived from the electrolytic treatment of 52,509,000 pounds of copper. This electrolytic copper was recovered from approximately 2,000,000 tons of "rock," an average of 0.29 fine ounce of silver per ton of "rock."

Production of silver, copper, "mineral," and "rock" in Michigan in 1914 and 1915.

Year.	Silver.	Copper.			"Mineral."		"Rock."
		Quantity.	Yield.		Quantity.	Yield.	
	Fine oz.	*Pounds.*	*Pounds per ton of "rock."*	*Per cent.*	*Pounds.*	*Per cent.*	*Short tons.*
1914	413,500	164,344,058	17.7	0.89	264,140,504	62.22	9,269,413
1915	585,933	265,283,378	21.5	1.08	400,178,132	66.29	12,334,700
Increase	172,433	100,939,320	3.8	.19	136,037,628	4.07	3,065,287

Three counties, Houghton, Keweenaw, and Ontonagon, contributed to the output of copper and silver. The following table shows the relative importance of these counties in output of copper and silver for 1914 and 1915:

Production of silver and copper in Michigan for 1914 and 1915, by counties.

1914.

County.	Silver.	Copper.			"Mineral."		"Rock."
		Quantity.	Yield.		Quantity.	Yield.	
	Fine oz.	*Pounds.*	*Pounds per ton of "rock."*	*Per cent.*	*Pounds.*	*Per cent.*	*Short tons.*
Houghton	382,625	130,276,142	17.8	0.89	213,045,909	61.1	7,322,343
Keweenaw	30,875	30,785,464	19.3	.97	44,332,470	69.4	1,595,584
Ontonagon	.....	3,282,452	9.3	.47	6,762,125	48.5	351,486
Total or average.	413,500	164,344,058	17.7	.89	264,140,504	62.2	9,269,413

1915.

Houghton	511,224	207,624,783	22.1	1.10	316,867,891	65.5	9,415,042
Keweenaw	74,709	47,726,865	20.6	1.03	67,504,365	70.7	2,313,368
Ontonagon	.....	9,931,730	16.4	.82	15,805,876	62.8	606,290
Total or average.	585,933	265,283,378	21.5	1.08	400,178,132	66.3	12,334,700

[1] Some of the terms used to designate the different materials entering into the mining industry differ for the Lake district from those employed in any other part of the country. Ore is known as "rock," or "copper ground" (if unmined); the product of concentration is known as "mineral;" the term "ore" ie used to designate the copper minerals (arsenides and sulphides) that occur to a limited extent in ths district. Large bodies of native copper are known as "mass" and smaller ones are designated as "barrel work." In this report the local terms will be used, as it does not seem desirable to employ the more usual terms to the exclusion of the local and a mixture of the two is confusing.

[2] The figures are based on the actual recovery of copper from "mineral" smelted and the estimated recovery from "mineral" that was not smelted during 1915.

In the following reviews of the operations at the individual mines of the district during 1914, the statements concerning the quantity, character, and tenor of "rock" developed, the quantity of rock stamped, the copper recovered per short ton of rock stamped, and the cost of production are based on the published reports of the companies. In the few cases in which reports are not published a general statement of the character of operations is made from the best information available.

HOUGHTON COUNTY.

In 1915 the mines of Houghton County produced 207,624,783 pounds of copper and 511,224 ounces of silver. The county occupies the central portion of the copper belt and contains 14 of the 22 mines that produced copper in 1915 and 9 of the 11 mines that produced silver.

"Rock" and "mineral" produced and average yield in silver and copper in Houghton County in 1914 and 1915.

Year.	Silver.	Copper.			"Mineral."		"Rock."
		Quantity.	Yield.		Quantity.	Yield.	
	Fine oz.	*Pounds.*	*Pounds per ton of "rock."*	*Per cent.*	*Pounds.*	*Per cent.*	*Short tons.*
1914	382,625	130,276,142	17.8	0.89	213,045,909	61.1	7,322,343
1915	511,224	207,624,783	22.1	1.10	316,867,891	65.5	9,415,042

The output of the county shows an increase of 77,348,641 pounds of copper and of 128,599 fine ounces of silver for 1915.

Calumet & Hecla.—The Calumet & Hecla Mining Co. has been one of the most successful copper mining companies in the world. In yield of copper and in dividends paid it ranks first among the copper mines of the country. To the close of 1915 the company had distributed $129,250,000 in dividends.

The company's ground contains three copper-bearing lodes—the Calumet & Hecla conglomerate, the Osceola amygdaloid, and the "Kearsarge" amygdaloid. A large percentage of the production in the past has come from the conglomerate lode, but with the decrease in copper content of this lode and its approaching exhaustion, the mining from the amygdaloid lodes has increased.

The company's annual report shows the details of operation for 1915 as follows:

During 1915 there were 3,188,583 short tons of "rock" stamped, yielding 71,030,518 pounds of copper, or an average of 22.28 pounds of copper per ton of "rock." This compares with a yield of 20.70 pounds for 1914. The total cost per pound of copper was 9.33 cents for 1915, as compared with 11.35 cents for 1914. In addition to the copper recovered from ore mined 1,582,802 pounds were recovered from old sands from Torch Lake, making a total output of 72,613,320 pounds.

The conglomerate lode is opened for a distance of nearly 2 miles along its strike by 10 inclined shafts and 1 vertical shaft. The

inclined shafts vary in depth on the dip of the lode from 6,102 to over 8,000 feet. The Red Jacket vertical shaft has a depth of 4,900 feet. The lode in the "Five Forties" tract, extending north from the company's main holdings, is developed by a slope shaft from the fifty-seventh level. The rock from this shaft is hoisted to the surface through the Red Jacket shaft.

In 1915 the conglomerate lode produced 1,739,984 tons of "rock," yielding 51,738,588 pounds of copper, or an average of 29.74 pounds per ton of "rock," as compared with 26.38 pounds for 1914.

The cost of producing copper from the conglomerate lode in 1915 was 8.69 cents per pound, as compared with 10.42 cents in 1914.

The Osceola lode is developed by 6 shafts, varying in depth from 1,460 to 3,274 feet. The lode has an average width of from 30 to 35 feet, though at some points it is much wider. The mineralization is confined principally to the hanging and the foot walls. The lode is opened by drift stopes along the hanging wall, where the mineralization is rather uniform. Crosscuts are extended to the footwall, where the mineralization is far less regular. During 1915 this lode produced 1,448,599 tons of "rock," yielding 19,291,930 pounds of copper, or 13.3 pounds per ton of "rock." This compares with a yield of 13.62 pounds for 1914. The average cost per pound of copper from this lode for 1915 was 9.71 cents, as compared with 10.20 cents for 1914.

The Kearsarge lode is opened by 3 shafts, varying in depth from 1,350 to 2,291 feet. Development on this lode in Calumet & Hecla ground has not been encouraging, though the lode has proved very productive farther north. There was no output from the Kearsarge lode in 1915.

The old recrushing plants treated 337,243 tons of coarse current tailings containing an average of 13.14 pounds of copper per ton; 1,352,869 pounds of copper were recovered, or an average of 4.01 pounds per ton of tailings treated. The cost per pound of copper recovered, exclusive of smelting and selling, was 6.52 cents.

The reclamation plant for treating old tailings from Torch Lake began operations in June. The tailings treated amounted to 181,732 tons, having an average copper content of 21.80 pounds per ton. A total of 1,582,802 pounds of copper was recovered, or an average of 8.71 pounds per ton, at an average cost of 4.02 cents per pound.

Work on the leaching plant was carried on, which is expected to be in operation in 1916. The plant is designed for a capacity of about 2,000 tons a day. The principal leaching agent to be used is ammonia.

Tamarack.—The Tamarack ground lies northwest of the Calumet & Hecla, and its operations are conducted on the underlays of the Calumet & Hecla conglomerate and the Osceola amygdaloid. Both lodes enter the property at considerable depth and are reached by vertical shafts, the different levels being connected with these shafts by crosscuts. The property is opened by 5 shafts, varying in depth from 3,409 feet (No. 1) to 5,308.5 feet (No. 5).

The company, although at a disadvantage on account of the great depth of the mine and the consequent high mining costs, has made a good record in dividends, which from 1888 to 1907 aggregated $9,420,000. Since the decline in the price of copper in 1907, however, the company has been unable to show a profit until 1912, when rela-

tively high prices again prevailed and copper was produced at a profit, and again in 1915.

The average cost per pound of production during the last five years has been 15.56 cents for 1911, 13.15 cents for 19.12, 16.60 cents for 1913, 29.08 cents for 1914, and 17.07 cents for 1915.

The mine was not producing at the beginning of the year and important production was not begun until well toward midyear.

During the year 217,027 tons of "rock" were stamped, yielding 6,139,824 pounds of "mineral" and 3,888,150 pounds of copper, or 17.9 pounds of refined copper per ton of "rock" stamped. This compares with a yield of 19.1 pounds in 1911, 18.8 pounds in 1912, 18.3 pounds in 1913, and 18.7 pounds in 1914.

The recrushing plant which was designed to consist of 32 Hardinge conical pebble mills and 92 Wilfley tables was not completed in 1915.

Osceola.—In 1915 the Osceola Co. operated the three branches—the Osceola, the South Kearsarge, and the North Kearsarge. Since 1878 this company has distributed dividends to the amount of $13,237,325.

The Osceola branch lies directly south of the Calumet & Hecla, and is worked on the Osceola amygdaloid. The property contains the Calumet & Hecla conglomerate lode, but the only portion of it in Osceola ground that has been shown to carry copper in paying quantities was worked out in the early days of the mine.

A total of 272,073 tons of "rock" was produced in 1915, yielding 3,882,069 pounds of copper, or an average of 14.27 pounds per ton, at a cost of 12.34 cents per pound.

The best showing in the mine in recent years was disclosed in ground 2,500 feet south of No. 6 shaft on the forty-second level and the three levels above. Early in 1916 practically half the regular product is coming from this territory. The No. 3 shaft was put in condition for operation in 1915.

The North Kearsarge lies north of the Wolverine, and is worked on the Kearsarge lode. No. 1 shaft has a depth of 3,873 feet, No. 3 shaft has a depth of 3,403 feet, and No. 4 shaft has a depth of 1,622 feet. A total of 4,550 feet of opening was accomplished on this branch in 1915. This branch produced 612,831 tons of rock, yielding 7,886,579 pounds of copper, or an average of 12.87 pounds per ton, at a cost of 10.99 cents per pound.

The South Kearsarge lies south of the Wolverine and east of the Centennial on the Kearsarge lode. No. 1 shaft has a depth of 2,820 feet, and No. 2 shaft has a depth of 1,992 feet.

This branch produced 476,185 tons of "rock," yielding 7,962,824 pounds of copper, or an average of 16.72 pounds per ton, at a cost of 7.77 cents per pound.

In 1915 the company treated 1,361,089 tons of "rock," producing 26,777,790 pounds of "mineral" and 19,731,472 pounds of copper, an average yield of 14.5 pounds of refined copper per ton of "rock." This compares with a yield of 14.8 pounds in 1911 and 1912, 15.4 pounds in 1913, and 13.5 pounds in 1914. The total cost of refined copper per pound was 10.03 cents for 1915, as compared with 10.79 cents in 1914.

Dividends were declared in 1915 to the amount of $1,057,650.

Centennial.—The Centennial ground lies north of the Calumet & Hecla and west of the South Kearsarge and the Wolverine. It

contains the Calumet & Hecla, the Osceola, and the Kearsarge lodes, the last being the only one of proved value in the property, and to this lode operations are at present confined.

At the close of 1915 the depth of No. 1 shaft was 3,821 feet. No work was done in the vicinity of this shaft during 1914. Shaft No. 2 had a depth of 4,293 feet at the close of 1915. A total of 2,366 feet of development was accomplished at this shaft.

Stoping operations were confined to points to the north of this shaft, with average results. Some exceptionally good ground was encountered on the thirty-first and thirty-second levels.

"Rock" to the amount of 150,191 tons was stamped during the year, producing 3,029,880 pounds of "mineral" and 2,347,500 pounds of refined copper, or 15.63 pounds refined copper per ton of "rock" stamped. The average cost of refined copper per pound was 12.45 cents, as compared with 12.56 cents for 1914.

Wolverine.—The Wolverine is located between the North Kearsarge and the South Kearsarge branches of the Osceola Co. Its operations are on the "Kearsarge" amygdaloid, though the West lode, parallel with the Kearsarge lode and about 80 feet to the west, has been opened to a small extent. The mine has the distinction of having the richest amygdaloid and, next to the Calumet & Hecla conglomerate, the richest rock, mined in the district. The Kearsarge lode is opened by 5 shafts, numbered from 1 to 5, from north to south; No. 1 is abandoned; No. 2, bottomed at the boundary at a depth of 1,700 feet, is used for handling men and supplies; No. 3 has attained a depth of 4,005 feet and can be sunk to a depth of 4,300 feet before reaching the boundary; No. 4 has a depth of 4,007 feet; No. 5 was sunk to a depth of 631 feet on the Osceola lode prior to June, 1913. The operations on the Osceola lode have thus far proved disappointing. The Kearsarge lode in the Wolverine ground shows great uniformity of mineralization, and is opened for the full length. In the upper levels the "rock" averaged from 16 to 18 pounds per ton, but as the lower levels were opened it showed marked improvement. The average for the fiscal year ending June 30, 1915, was 18.23 pounds per ton.

During the fiscal year ending June 30, 1915, there were stamped 397,614 tons of "rock," producing 9,734,850 pounds of "mineral," yielding 7,250,866 pounds of copper, or 18.23 pounds of refined copper per ton of "rock" stamped. The total cost per pound of refined copper was 8.43 cents.

Since its organization to June 30, 1915, the company has produced 144,661,618 pounds of copper. Operations have resulted in profits amounting to $8,887,310, of which $8,100,000 has been paid in dividends. Two dividends paid during the fiscal year amounted to $360,000.

Franklin.—The Franklin and the Rhode Island, which is controlled by the Franklin, are located southeast of the La Salle. The property carries several lodes, but in the past exploration has been principally on the "Pewabic" amygdaloid and the Allouez or "Albany and Boston" conglomerate.

Exploration was carried on in the conglomerate lode from the twenty-seventh to the thirty-seventh levels, inclusive, and is stated to have developed reserves of average value amounting to 600,000 tons.

The exploratory crosscut on the thirty-second level was advanced 2,638 feet. Seven beds were cut that carried copper in small quantity, and two carried sufficient copper to warrant drifting.

An output of 122,018 tons of "rock" stamped, yielded 1,314,969 pounds of copper.

Quincy.—The Quincy mine is situated just north of the east-west arm of Portage Lake. The property is traversed by most of the lodes of the district, but has derived its principal output in the past from the Pewabic lode, with a small quantity from the West lode.

The ground developed was of the same general character as that of the previous year.

Dividends to the amount of $880,000 were paid in 1915. The total disbursement in dividends from 1862 to 1915 is $21,777,500.

In 1915 there were mined 1,269,000 tons of "rock," which yielded 34,251,765 pounds of "mineral" and 22,054,813 pounds of copper.

Isle Royale.—The Isle Royale mine is situated south of the east-west arm of Portage Lake, near Houghton. The property contains several copper-bearing lodes, of which the Isle Royale is the main producer at present.

A total of 14,446 feet of openings was acomplished during 1915.

The first unit of the new mill replacing the one destroyed by fire late in 1914 was put in operation on June 7, 1915, the second unit on July 9, and the third on August 26.

During 1915 "rock" amounting to 680,270 tons was treated, yielding 13,727,832 pounds of "mineral" and 9,342,106 pounds of copper, or an average of 13.7 pounds of copper per ton. The average cost per pound of copper was 14.94 cents, as compared with 13.05 cents in 1914.

Dividends were paid to the amount of $150,000.

Baltic, Champion, and Trimountain.—These three mines are located on the Baltic lode southwest of Houghton and are under the same management as that of the Copper Range Consolidated Co. The Baltic is an exceptionally strong lode, having a stoping width varying from 15 to 80 feet. The lode has produced considerable "mass" copper, and also contains veinlets of copper minerals, including chalcocite, bornite, and copper arsenides. These minerals are recovered in the mill, and the arsenides probably account in part for the arsenical character of the Copper Range output.

During 1915 the Baltic operated 3 shafts with depths of 2,566 feet for No. 2, 2,926 feet for No. 3, and 2,667 feet for No. 4.

A total of 378,443 tons of "rock" was stamped, producing 12,028,-947 pounds of refined copper, or 31.79 pounds of refined copper per ton of "rock" stamped. The cost per pound of refined copper was 9.5 cents.

Since its organization to the close of 1915 the Baltic company has produced 188,158,362 pounds of copper at a profit of $9,390,516, of which $7,950,000 has been distributed as dividends.

The Trimountain is also opened by 3 shafts, with depths of 2,859 feet for No. 2, 2,563 feet for No. 3, and 2,548 feet for No. 4, at the close of 1915. Openings made during the year showed about average values.

A total of 349,684 tons of "rock" was stamped, yielding 8,302,896 pounds of refined copper, or an average of 23.75 pounds per ton. The average cost per pound of copper was 9.52 cents.

Since its organization the company has produced 101,809,470 pounds of copper at a profit of $2,608,144, of which $1,450,000 has been disbursed as dividends.

The Champion, controlled jointly by the Copper Range Consolidated Co. and the St. Mary's Mineral Land Co., is opened by 4 shafts with depths varying from 2,239 to 2,514 feet, at the close of 1915. The openings made during the year were in average ground.

A total of 923,743 tons of "rock" was stamped, yielding 33,417,599 pounds of refined copper, a yield of 36.17 pounds per ton of "rock" stamped. The cost of refined copper per pound was 6.3 cents.

From its organization to the close of 1915 the Champion company has produced 225,272,074 pounds of copper at a profit of $13,315,868, of which $11,500,000 has been disbursed as dividends.

Superior.—The Superior is located northeast of the Baltic. The ground on this property is being opended by 2 shafts, and at the close of 1915 No. 1 shaft had reached a depth of 2,469 feet and No. 2 a depth of 1,628 feet.

During the year 212,051 tons of "rock" were stamped, producing 3,866,484 pounds of copper, or 18.23 pounds per ton of "rock" stamped. The cost of copper a pound was 12.29 cents.

La Salle.—The La Salle company produced 80,959 tons of "rock," yielding 782,493 pounds of copper, or an average of 9.67 pounds per ton of "rock."

Winona.—The Winona produced 102,594 tons of "rock," which yielded 3,032,045 pounds of "mineral" and 1,722,638 pounds of refined copper, an average of 16.79 pounds of refined copper per ton of "rock" stamped.

Other companies.—Other companies were active in development work, especially during the latter part of the year.

KEWEENAW COUNTY.

In 1915 Keweenaw County produced 47,726,865 pounds of copper and 74,709 fine ounces of silver. The county occupies the northern portion of the copper belt. This section of the belt produced considerable copper in the early days of lake mining, but of late years it has furnished a comparatively small percentage of the total output. Developments, however, indicate that the county should increase in importance in the future.

"Rock" and "mineral" produced and average yield in silver and copper in Keweenaw County in 1914 and 1915.

Year.	Silver.	Copper.			"Mineral."		"Rock."
		Quantity.	Yield.		Quantity.	Yield.	
	Fine oz.	*Pounds.*	*Pounds per ton of "rock."*	*Per cent.*	*Pounds.*	*Per cent.*	*Short tons.*
1914	30,875	30,785,464	19.3	0.97	44,332,470	69.4	1,595,584
1915	74,709	47,726,865	20.6	1.03	67,504,365	70.7	2,313,368

Ahmeek.—The Ahmeek mine, lying north and east of the Allouez, is located on the Kearsarge lode. The lode is opened by 4 shafts; No. 1 has a depth of 2,533 feet; No. 2, a depth of 2,775 feet; No. 3, 2,210 feet; and No. 4, 2,158 feet.

During the year mill construction was nearly completed. A total of 948,874 tons of "rock" was stamped, yielding 32,292,325 pounds of "mineral" and 21,800,492 pounds of refined copper, or 23 pounds of refined copper per ton of "rock." The total cost per pound of refined copper was 7.96 cents.

During the year dividends were declared to the amount of $1,650,000. Total dividends to the close of 1915 amount to $4,050,000.

Allouez.—The Allouez mine is north of the North Kearsarge, and, as in recent years, operations were confined to the Kearsarge lode. As this lode does not outcrop on Allouez property, the shafts were started in the hanging wall at a steep angle and flattened to the dip of the copper-bearing bed just before reaching it. This plan avoids the expense of long crosscuts necessitated by vertical shafts.

A total of 534,705 tons of "rock" was stamped during 1915, yielding 14,506,440 pounds of "mineral," or 10,043,459 pounds of refined copper, an average of 18.78 pounds of refined copper per ton of "rock." The total cost per pound of refined copper was 9.31 cents.

Mohawk.—The Mohawk mine, lying east of the Ahmeek, carries the outcrop of the Kearsarge lode for more than a mile and also contains several cross fissures carrying arsenides of copper, which have been mined to a considerable extent in the past. Operations were conducted through 6 shafts.

A total of 829,789 tons of "rock" was stamped, yielding 20,705,600 pounds of "mineral," and 15,882,914 pounds of copper, or an average of 19.15 pounds per ton of "rock." The total cost per pound of refined copper was 7.21 cents.

Since organization the Mohawk company has produced 133,306,881 pounds of copper, at a profit of $5,638,784, of which amount $3,875,000 has been disbursed as dividends.

ONTONAGON COUNTY.

In 1915 Ontonagon County produced 9,931,730 pounds of copper. Ontonagon County contains the southwestern portion of the copper belt. This portion has not been so thoroughly developed as the others, and consequently the geology is less understood than in the more northern counties. So far as developed, the lodes are more "bunchy" than to the north and have produced a relatively high percentage of mass copper. The production of 1915 was derived wholly from amygdaloid rock.

"Rock" and "mineral" produced and average yield in copper in Ontonagon County in 1914 and 1915.

Year.	Copper.			"Mineral."		"Rock."
	Quantity.	Yield.		Quantity.	Yield.	
	Pounds.	*Pounds per ton of "rock."*	*Per cent.*	*Pounds.*	*Per cent.*	*Short tons.*
1914	3,282,452	9.3	0.47	6,762,125	48.5	351,486
1915	9,931,730	16.4	.82	15,805,876	62.8	606,290

Mass.—The Mass mine, adjoining the Adventure on the southwest, carries six known copper-bearing amygdaloid lodes—the Knowlton, the Mass, the North Butler, the Butler, the Ogima, and the Evergreen. In addition, the position of the property makes it probable that the newly discovered lodes in this part of the district may be present in the Mass ground. The main developments for the year were from "B" and "C" shafts on the Butler and Evergreen lodes and continued to show as satisfactory conditions with respect to copper values as in previous years.

A total of 323,335 tons of "rock" was stamped in 1915, yielding 7,105,295 pounds of "mineral" and 4,638,452 pounds of refined copper, an average of 14.35 pounds of refined copper per ton of "rock" stamped.

The average cost of refined copper, including construction, was 14.77 cents per pound.

Victoria.—The Victoria is the most southwesterly of the Lake mines that have made important production. The first attempts at copper mining in the district are said to have been made at this locality, though its recent period of productiveness began in 1906. The present production is from the Forest lode. "Rock" amounting to 133,984 tons was stamped, yielding 2,262,244 pounds of "mineral."

White Pine Copper Co.—The mill of the White Pine Copper Co. was put in operation in April, 1915. It consists of two units having a nominal capacity of 500 tons each. There were 114,039 tons of "rock" treated, yielding 2,824,145 pounds of copper, or an average of 24.76 pounds per ton of "rock."

The total cost per pound of refined copper was 16.64 cents.

MISSOURI.

By J. P. Dunlop.

PRODUCTION.

VALUE.

The value of the mine production of silver, copper, lead, and zinc in Missouri in 1915 was $53,683,420, compared with $25,874,864 in 1914. The value of the copper production showed an increase of $64,464, that of silver a decrease of $4,544, and the value of the lead increased $4,757,624, so that the large increase in the total value was caused mainly by the much larger output and the higher average price of spelter in 1915, compared with 1914. The recoverable lead content of Missouri lead concentrates sold in 1915 was equal to 41 per cent of the smelter production of primary lead in the United States derived from domestic ores, and the recoverable spelter content from Missouri zinc concentrates sold in 1915 was nearly 30 per cent of the primary spelter produced by smelters from domestic ores in 1915.

SILVER AND COPPER.

Mine production of silver and copper in Missouri, 1910–1915.

Year.	Copper.		Silver.		Lead concentrates, silver-bearing (short tons).
	Quantity (pounds).	Value.	Quantity (fine ounces).	Value.	
1910	94,452	$11,955	33,096	$17,872	35,002
1911	640,411	80,051	49,867	26,430	51,109
1912	440,725	72,719	35,438	21,794	31,183
1913	576,204	89,312	35,620	21,514	35,854
1914	44,463	5,914	61,168	33,826	61,995
1915	402,160	70,378	57,756	29,282	64,377

For several years prior to 1913 the entire silver production had been derived from refining lead concentrates, but in 1913 a small quantity of silver was obtained from oxidized copper ore shipped by the Cornwall mine of Ste. Genevieve County and in 1914 some ore of the same character was shipped from the Swansea mine. In 1915 some copper matte containing silver was shipped by the Missouri Copper Mining Co. The quantities given in the fourth column of the foregoing table are those of recovered silver. The silver content of the lead ores is so small that it is disregarded in the assay and sale of the concentrates. For this reason the smelter reports must be relied upon for the silver production. As may be seen by inspection of the table, the quantity of silver produced in any year bears no direct ratio to the quantity of lead concentrates smelted during that year. The reason for this is that the silver content is so small in quantity that the silver bullion is stored and refined in batches. If a series of years be taken into account, the concentrates are seen to average about 1 ounce of silver to the ton.

The production of copper in Missouri in 1915 was 402,160 pounds, valued at $70,378, as compared with 44,463 pounds, valued at $5,914 in 1914. The mines of the North American Lead Co., which produced some copper as well as nickel and cobalt in the years 1908 and 1909, were idle during 1915. Nearly all the copper output for 1915 was derived from concentrates recovered in dressing lead ore mined in St. Francois County, in southeastern Missouri. Some copper ore was mined by the Missouri Copper Mining Co. near Sullivan, in Franklin County. This ore was reduced to matte and shipped to smelters for refining. In addition to the copper the matte is reported to have yielded some silver and trifling values in gold.

LEAD AND ZINC.

Production of lead and zinc in Missouri in 1915.

District.	Ore.							
	Lead concentrates.				Zinc concentrates.			
	Galena.		Carbonate.		Sphalerite.		Silicate and carbonate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Southwestern Missouri:								
Alba-Neck City	301	$14,610	.....	.....	15,685	$1,131,720	125	$5,454
Ash Grove-Everton	25	1,400	.....	.....	.....	.....	475	23,200
Aurora	306	12,187	7	$242	892	81,178	3,993	178,802
Carl Junction	44	2,515	.....	.....	1,359	83,391	.....	.....
Carthage	10	567	.....	.....	1,153	92,992	370	21,846
Cave Springs	77	4,006	.....	.....	2,191	185,242	.....	.....
Duenweg-Porto Rico	3,120	170,998	.....	.....	27,789	2,285,151	1,507	70,161
Granby	222	9,625	85	3,088	7,587	511,169	10,923	586,116
Joplin	6,085	325,731	20	392	49,074	3,825,971	3,460	149,092
McDowell-Stark City	4	265	.....	.....	16	1,800	15	900
Oronogo	2,135	117,931	.....	.....	12,834	1,030,047	.....	.....
Sarcoxie-Reeds	1	25	.....	.....	2,002	151,563	251	12,030
Sherwood-Thoms Station	555	31,863	.....	.....	4,813	349,846	.....	.....
Spring City-Beef Branch	568	29,846	100	3,175	1,964	142,104	2,388	121,609
Springfield	196	9,546	.....	.....	1,402	92,425	.....	.....
Spurgeon	78	3,755	3	103	1,291	77,717	2	85
Webb City-Carterville-Prosperity	20,476	1,061,617	.....	.....	103,923	7,787,651	.....	.....
Wentworth	.....	.....	.....	.....	1,091	86,980	562	25,243
Zincite-Klondike	45	2,295	.....	.....	6,000	464,409	.....	.....
Christian, Ozark, and Taney counties	.....	.....	.....	.....	2	100	280	9,460
Central and southeastern Missouri	34,248	1,798,782	215	7,000	241,068	18,381,456	24,351	1,203,998
	278,104	12,773,579	.....	.....	43	1,064	1,061	39,460
State total, 1915	312,352	14,572,361	215	7,000	241,111	18,382,520	25,412	1,243,458
1914	279,659	11,138,386	195	4,718	189,765	7,351,726	19,648	415,185

District.	Metal content.[a]			
	Lead.		Zinc.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Southwestern Missouri:				
Alba-Neck City	228	$21,432	8,338	$2,067,824
Ash Grove-Everton	21	1,974	165	40,920
Aurora	220	20,680	1,849	458,552
Carl Junction	34	3,196	713	176,824
Carthage	8	752	759	188,232
Cave Springs	56	5,264	1,186	294,128
Duenweg-Porto Rico	2,410	226,540	15,291	3,792,168
Granby	231	21,714	7,766	1,925,968
Joplin	4,790	450,260	27,128	6,727,744
McDowell-Stark City	3	282	25	6,200
Oronogo	1,651	155,194	6,844	1,697,312
Sarcoxie-Reeds	.....	.....	1,161	287,928
Sherwood-Thoms Station	444	41,736	2,477	614,296
Spring City-Beef Branch	504	47,376	1,874	464,752
Springfield	160	15,040	787	195,176
Spurgeon	62	5,828	661	163,928
Webb City-Carterville-Prosperity	15,677	1,473,638	54,933	13,623,384
Wentworth	.....	.....	785	194,680
Zincite-Klondike	35	3,290	3,102	769,296
Christian, Ozark, and Taney counties	.....	.....	84	20,832
Central and southeastern Missouri	26,534	2,494,196	135,928	33,710,144
	183,906	17,287,164	372	92,256
State total, 1915	210,440	19,781,360	136,300	33,802,400
1914	192,612	15,023,736	105,994	10,811,388

[a] In calculating the metal content of the ores from assays allowance has been made for smelting losses in the case of zinc but not in the case of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily quotations at New York. The price of zinc for 1915 is the average sales price reported by smelters.

The total value of the recoverable metallic content of the lead and zinc concentrates produced in Missouri in 1915 was $53,583,760, an increase of $27,748,636 over that of 1914. The production of lead concentrates in Missouri in 1915 (of which all but 215 tons was galena) was 312,567 short tons, valued at $14,579,361, as compared with an output of 279,854 tons, valued at $11,143,104 in 1914, an increase of 33,713 tons in quantity and of $3,436,257 in value. Of this production in 1915 of lead concentrates 278,104 tons, valued at $12,773,579, was derived from southeastern and central Missouri, an increase of 28,939 tons in quantity and of $3,063,454 in value. The average metal content of the lead concentrates from these districts was 66.5, as compared with 67.6 in 1914, and the value per ton in 1915 was $45.89, an increase of $6.93. The quantity of recoverable lead in southeastern and central Missouri concentrates in 1915 amounted to 183,906 tons, an increase of 15,467 tons. The output was equal to more than 36 per cent of the primary lead smelted or refined from domestic ores in the United States in 1915.

Shipments of lead concentrates from southwestern Missouri were 34,463 tons, valued at $1,805,782, as compared with 30,689 tons, valued at $1,432,979, in 1914. The lead carbonate concentrates amounted to 215 tons, valued at $7,000, an increase of 20 tons. The quantity of recoverable lead from southwestern Missouri, or the Joplin region, was 26,534 tons, valued at $2,494,196, an increase of 2,361 tons. The average metal content of the galena concentrates from southwestern Missouri was 77.5 per cent and the average price per ton was $52.52, or $5.68 more per ton than in 1914.

The quantity of zinc blende concentrates sold from Missouri mines in 1915 was 241,111 tons, valued at $18,382,520, an increase of 51,345 tons in quantity and of $11,030,794 in value, when compared with the figures for 1914. All the blende concentrate except 43 tons was produced in southwestern Missouri. The average price received per ton was $76.24 and the average recoverable zinc content reported by the sellers was 58.7 per cent. The average price paid per ton in 1914 was $38.74 and the average recoverable zinc content was 58.1 per cent.

A larger quantity of high-grade concentrates was shipped from certain districts than in 1914. The zinc content of the sphalerite concentrates derived from "sheet-ground" mines, which was 58.6 per cent in the years 1911 and 1912, declined to 58.3 per cent in 1913 and increased to 58.4 per cent in 1914 and to 59.1 per cent in 1915. The average price received for sphalerite concentrates in 1915 was nearly $38 a ton more than in 1914.

The zinc carbonate and silicate concentrates sold in 1915 amounted to 25,412 tons, valued at $1,243,458. This was 5,764 tons more in quantity and $828,273 more in value than the sales in 1914. The output in 1915 was mainly from southwestern Missouri, the shipments from southeastern Missouri being only 1,061 tons, valued at $39,460, as compared with 497 tons, valued at $11,282, in 1914. The average metal content of the zinc carbonate and silicate concentrates was 39.3 per cent in 1915. The average value per ton in 1915 was $45 as compared with $21.13 in 1914.

The combined value of lead and zinc concentrates from southeastern and central Missouri in 1915 (which produced about 89 per

cent of the lead concentrates) was $12,814,103, or $3,091,996 more than in 1914.

The total value of the southwestern Missouri lead and zinc concentrates was $21,391,236, as compared with $9,187,908 in 1914, an increase of $12,203,328.

The total quantity of crude ore or "dirt" mined and treated in 1915 amounted to 15,573,700 short tons, an increase of about 4,080,000 tons, or approximately 35 per cent more than the quantity mined and treated in 1914. As the total amount received for all classes of lead and zinc concentrates sold in 1915 was $34,205,339, the average value per ton of crude ore or "dirt" mined and treated was $2.20, compared with $1.65 in 1914, $1.72 in 1913, and $1.86 in 1912.

The small quantity of copper ore mined and shipped in 1915 is excluded from these calculations.

In the following tables showing the tenor of crude ore ("dirt") and concentrates from Missouri it has been considered advisable to segregate the ores of different nature. For instance, the disseminated lead ore of southeastern Missouri differs radically from the lead and zinc ores of the so-called "soft-ground" deposits of southwestern Missouri, and these in turn differ from the "sheet ground" deposits of the same region. Each class of ore has its peculiar problems of mining and ore dressing. This fact makes desirable the separate treatment of the statistical data. In general, the tables reflect very closely the conditions of the industry.

Tenor of crude lead and zinc ore and concentrates produced in southwestern Missouri in 1914 and 1915.[a]

		1914	1915
SOFT GROUND.			
Total crude ore	short tons	3,179,830	4,004,900
Total concentrates in crude ore	per cent	4.61	3.88
Lead	do	.48	.32
Zinc	do	4.13	3.56
Metal content of crude ore	do	2.64	2.26
Lead	do	.38	.25
Zinc	do	2.26	2.01
Average lead content of galena concentrates	do	78.6	79.2
Average lead content of lead carbonate concentrates	do	51.3	58.1
Average zinc content of sphalerite concentrates	do	57.9	57.7
Average zinc content of silicates and carbonates	do	38.6	39.3
Average value per ton:			
Galena concentrates		$46.16	$48.19
Lead carbonate concentrates		$24.19	$32.56
Sphalerite concentrates		$38.65	$72.68
Zinc silicates and carbonates		$21.13	$45.00
SHEET GROUND.			
Total crude ore	short tons	3,594,170	6,501,000
Total concentrates in crude ore	per cent	2.69	2.25
Lead	do	.44	.34
Zinc	do	2.23	1.91
Metal content of crude ore	do	1.65	1.38
Lead	do	.35	.25
Zinc	do	1.30	1.13
Average lead content of galena concentrates	do	79.3	76.4
Average zinc content of sphalerite concentrates	do	58.4	59.1
Average value per ton:			
Galena concentrates		$47.38	$54.63
Sphalerite concentrates		$38.86	$78.79

[a] Including also the small production of lead and zinc ores in southeastern and central Missouri.

Tenor of crude lead ore and concentrates in southeastern Missouri disseminated lead ore in 1914 and 1915.

		1914	1915
Total crude lead ore	short tons	4,718,300	5,067,800
Galena concentrates in crude ore	per cent	5.27	5.47
Lead content in crude ore	do	3.56	3.62
Average lead content of galena concentrates	do	67.6	66.5
Average value per ton of galena concentrates		$38.96	$45.89

In Mineral Resources for 1914, volume 1, pages 72–77, and 97–100, was given a brief history of lead and zinc mining in the southeastern Missouri and Joplin regions, together with data relating to the total lead and zinc production, the mining and milling practice, and the methods of selling ore and concentrates. The separate chapter entitled "Silver, copper, lead, and zinc in the central States in 1914" is available for distribution and can be obtained upon application to the Director, United States Geological Survey, Washington, D. C.

SOUTHWESTERN MISSOURI.

AREA, ORES, DEPOSITS.

The southwestern Missouri lead and zinc area includes the largest part of the Joplin region, the remaining portion lying in southeastern Kansas and in northeastern Oklahoma. The Missouri part of the region was first developed, then that in Kansas, followed at a considerably later period by mining in Oklahoma.

The ore in southwestern Missouri occurs in the Mississippian Boone limestone, in beds of Kinderhook age. The ore deposits are found in Jasper, Newton, Lawrence, Greene, and adjoining counties. This area produced in 1915 about four-fifths of the lead and zinc ore raised in the Joplin region.

The lead ores are galena, with a small quantity of lead carbonate, locally known as "dry bone." The zinc ores are sphalerite, or zinc blende, or "jack," zinc carbonate (smithsonite), and zinc silicate (calamine), both of the latter locally called "silicate." The galena contains but a small fraction of an ounce of silver to the ton of lead concentrates, and although ordinarily it is not desilverized, yet occasionally the refineries find it advantageous to add lead from the Joplin region to their charges without, however, making any record of the silver content. In this way an unknown but small quantity of silver is recovered from southwestern Missouri lead ore. The zinc ores, sphalerite, smithsonite, and calamine contain notable quantities of cadmium, being fully as rich in this respect as the zinc ores of Silesia, which are the source of the cadmium production of Europe. The discussion of the cadmium content of these ores is taken up more fully in the chapter entitled "Cadmium," in Mineral Resources for 1908.

The ore deposits of the Joplin district vary in character with the depth of mining. The shallower ores beginning at the surface are universally pockety and are found in residual clays or in "runs" in the basal breccias of the region. The breccias and the forms of the

"runs" are largely, if not altogether, due to solution of the limestone strata. One form of run, which is fairly numerous, is the "circle" deposit, which, in the popular view, has come to be nearly synonymous with rich deposits. Small veins, vertical sheets, and thin crevice deposits are often met with in prospecting, but unless they develop into stringers leading into paying ore bodies are forgotten in the multitude of rich pockety deposits which the district has yielded. The blanket deposits or "sheet ground" are found in the Grand Falls chert member of the Boone limestone at depths varying from 100 to 275 feet, depending on the topography and the geologic structure. Below this horizon there are, in the beds of Kinderhook age, deposits of disseminated ore. They have been found in prospect shafts or drill holes near Springfield, Aurora, Granby, Carterville, Joplin, Hornet, and Cave Springs, in Missouri; at Galena, in Kansas; and at Quapaw, in Oklahoma.

Lead and zinc concentrates produced in the Missouri part of the Joplin region, 1907–1915.

	Quantity (short tons).	Value.
Lead concentrates	327,672	$17,769,243
Sphalerite concentrates	2,001,123	90,726,368
Zinc carbonate and silicate concentrates	193,132	5,201,247
	.....	113,696,858

The average price per ton received for sphalerite concentrates during the period 1907 to 1915 was $45.34 and that for zinc silicate and carbonate was $26.93.

ASSAYS.

Several of the assayers in the Joplin district make a practice of saving the remnants of blende samples analyzed during the year. At the close of the year the lot is thoroughly mixed and carefully sampled, from which sample an average or composite assay for the year is made. Each assay thus represents several thousand lots. Two representative series of such composite assays are given below. In most cases each sample included in the composite assay represents a carload lot of concentrates.

The first series, by W. W. Petraeus and Evans W. Buskett, of Joplin, gives the result of analyses of composite samples from the general district for the last 16 years. The analyses for 1897–1905, inclusive, were published in the Lead and Zinc News, volume 9, page 8, January 15, 1906. The analyses for 1906–1913 were kindly communicated by Mr. Petraeus and that for 1914 and 1915 by Mr. Buskett. Iron was not taken into account until 1900. Some 400 scattering assays, made in 1895–96, are excluded from the table.

Composite assays of zinc blende from the Joplin region, 1897–1915.

[W. W. Petraeus, analyst, 1897-1913; Evans W. Buskett, analyst, 1914-15.]

Year.	Number of lots in the composite.	Percentage.				
		Zinc.	Iron.	Lead.	Copper.	Cadmium.
1897	600	56.64				
1898	1,299	56.99				
1899	3,715	56.67				
1900	3,500	57.36	0.22			
1901	3,683	57.53	2.02			
1902	5,776	57.08	2.24			
1903	6,014	57.30	2.00			
1904	6,220	57.24	2.10			
1905	4,628	57.97	1.84	1.00	0.001	0.198
1906	5,644	57.2	2.00			
1907	6,813	56.8	1.93			
1908	7,837	56.4	1.76			
1909	9,002	56.3	2.00			
1910	8,892	56.6	2.10	1.02	.06	.399
1911	8,920	57.1	2.40			
1912	9,474	57.7	2.40			
1913	7,010	57.1	2.40			
1914	420	56.40	2.70			
1915	1,806	56.76	2.36			

The next series of composite assays was communicated by Prof. W. George Waring, of Webb City. The original samples were of ores from the different camps of the district except where otherwise indicated. The methods used in making these assays have been published.[1]

Composite assays of zinc blende from the Joplin region, 1900–1915.

[W. George Waring, analyst.]

Year.	Number of lots in the composite.	Percentage.				
		Zinc.	Iron.	Lead.	Cadmium.	Copper.
1900	3,894	57.30	3.03			
1901	5,172	56.00	3.30			
1901	2,577	55.30	3.86			
1901	[a] ±2,000	55.90	3.47			
1902	2,270	57.08	2.65	0.904	0.337	0.050
1903	2,145	57.75	2.32	1.072	.388	.049
1904	[a] 3,800	58.26	2.23	.701	.304	.049
1904	[b] 2,691	58.46	1.97	.720	.430	.050
1904	1,984	58.95	2.10			
1905	4,520	58.95	2.00			
1906	4,638	58.40	2.20			
1906	3,968	58.20	2.29			
1907-8	±4,000	58.70	2.00			
1909		[c] 57.40	2.60			
1910	6,377	[c] 57.90	2.60			
1911	5,653	58.20	2.35	.856	.450	.034
1912	6,709	56.72	2.50	1.070	.256	.022
1913	7,364	56.82	2.81	1.112	.209	.036
1914	7,981	56.56	2.80	1.30	.287	.038
1915	9,240	57.19	2.40	.985		

[a] Joplin. [b] Webb City. [c] The composite sample included some lots of silicate ores.

[1] Waring, W. G., The volumetric determination of zinc: Am. Chem. Soc. Jour., vol. 26, No. 1, January, 1904. In addition to the composite assays for 1902 and 1903, shown in the table, the article gives the lead, copper, and cadmium content of a number of ores from individual mines in Missouri, Kentucky, and Illinois.

The complete analysis of the composite sample of the 3,800 lots of concentrate from the Joplin region in 1904, sampled by C. V. Millar and analyzed by Waring, is as follows:

Analysis of composite sample of zinc blende from the Joplin region.

Zinc	58.26	Calcium carbonate	1.88
Cadmium	.304	Magnesium carbonate	.85
Lead	.70	Barium sulphate	.82
Iron	2.23	Silica	3.95
Manganese	.01		
Copper	.049		99.773
Sulphur	30.72		

PRICES AND PRODUCTION.

The year 1915 was one of unexampled prosperity for the mining industry in the Joplin region. In common with other regions of the United States in which zinc ores were mined, production increased rapidly, especially as high-grade ores composed a large percentage of the output in southwestern Missouri. The increased cost of mining and the difficulty of obtaining labor supplies and machinery hampered operations. Extremely wet weather, a brief strike of the miners, and a general tendency to think that higher prices should be paid for concentrates were mere incidents compared with the unusual profits to be made. There was very little speculation in mining stocks, and most of the new companies were composed of a few persons who supplied the money and received the profits. There were, however, many sales of land and transfers of mining leases in addition to considerable drilling.

The demand for high-grade sphalerite concentrates induced the miners to reopen the "sheet ground" mines shut down during the years of low prices and to operate every mine of this character at full capacity. Prospecting was active in the "soft ground" districts, but investors seeking properties preferred to purchase or lease old mines which merely required pumping out and equipment, or new mines which had been so far developed that shipments could be made from them within a short time. Many small operators after opening mines at small expense sold them to others at prices which appeared exorbitant but which in reality proved to be bargains for the purchasers. The steady demand for and high price of zinc concentrates created a healthy boom in nearly all districts. The profits of the big operators were abnormal, but hundreds of mines worked by individuals or small companies shared the general prosperity. Old dumps at abandoned mines attracted boys and old men who made more than good wages by culling the waste rock. Mills to treat the many large tailing piles were a good investment, whereas in former years it had been impossible to rerun the tailings. Some of these new tailing mills were of large capacity and unusually well equipped. There was a general tendency to make a more thorough recovery from the "dirt" treated by means of tables, thickeners, and agitators. The cost of such equipment was soon repaid by the increased yield of concentrates. The "sheet ground" mine operators naturally were in the van in making such improvements, but "soft ground" miners also were conspicuous for their efforts along such lines. Not only

was it good policy to increase their prevailing large profits, but also to insure cheaper mining and milling when the boom was over.

It is undoubtedly a fact that, although operations were carried on with a feverish desire to crowd mines and milling plants to their full capacity, the percentage of recovery of concentrates from "dirt" mined and milled was greater than in former years.

The reported sales of galena and lead carbonate concentrates from southwestern Missouri were slightly more than in 1914. The sales of zinc carbonate and silicate increased 5,000 tons and the shipments of sphalerite increased more than 51,000 tons. The stocks of zinc concentrates in the ore bins at the beginning of the year were approximately 11,000 tons, and at the end of the year 6,000 or 7,000 tons. There was more galena concentrate unsold at the end of 1915 than was usual, for prices were comparatively low. These accumulations are estimated to have been 1,500 tons, or 1,000 tons more than ordinarily.

The production of southwestern Missouri showed a steady increase, opening with a weekly output of about 4,000 tons of sphalerite concentrates, 400 tons of zinc silicate, and 500 tons of galena, and closing with an approximate weekly yield of 6,500 tons of sphalerite, 550 tons of zinc silicate, and 750 tons of galena.

The average quoted base price for 60 per cent sphalerite concentrates was highest in June, when some concentrates sold for $135. The significant feature of the ore market during the year was the wide margin between the base prices offered for the high and for the medium and lower grades of concentrates. The spread had usually been comparatively small, but in 1915 it was generally $10 to $15 a ton and frequently the difference was as great as $15 or $20 a ton. This was due to the imperative demand by the smelters for concentrates free from lead or containing less than 1 per cent lead. Some weeks it was difficult to sell the low-grade ore even at the quoted low base price. The Joplin region was fortunate in that only a small quantity of the sphalerite concentrate produced contains less than 55 or 56 per cent zinc content. Much of this concentrate, however, does carry more than 1 per cent of lead.

In the first week in January, 1915, the base prices quoted were from $48 to $52 a ton. The price advanced steadily in January and February to as high as $75, then receded in March to $55 and $60. In May it closed at $75 to $80. The prices in June reached the maximum. In July they receded to $90 and $110; in August they declined to $70 and $80; in September and October they were fairly steady at an advance of about $10 a ton. Prices again advanced in November, and the year closed with base prices ranging from $85 to $115. The average base prices for the year were approximately double those of any preceding year.

Base prices for calamine or zinc carbonate and silicate concentrates follow generally the variations in sphalerite quotations. In 1915, however, this was not always so, for more smelters were in the market for this class of ore. This was owing to the fact that such concentrates do not require to be roasted before smelting, and also because the roasting facilities of some smelters were not on a par with their smelting capacity.

Calamine concentrates were consequently in steady demand when low-grade sphalerite was not, and at such times the calamine concentrates brought nearly as much as sphalerite having a much higher zinc content. The lowest base prices were in January, when they ranged from $22 to $32 a ton, and the highest was $82 in August.

The quoted price for 80 per cent galena concentrates showed a low range during most of the year. The high base in January and February was $47 a ton, advancing to $51 in May. In June the quoted price was as high as $72, but soon declined to $60 in July and to as low as $45 in August. In September the price held steadily at $50, advancing to $55 in October. From November until the end of the year $60 to $72 was paid for galena concentrates.

Ore buyers stated that in many districts the production of lead was much smaller than usual, and this proved to be true, for the output of galena from "soft ground" was less than it was in 1914.

Apparently the increased yield of galena concentrates from southwestern Missouri was entirely due to the more extended working of "sheet ground," especially in the Webb City district.

The average price paid for sphalerite or blende in 1915 was $76.25, as compared with $38.74 in 1914, $40.70 in 1913, and $50.44 in 1912; and for zinc silicate or carbonate concentrates it was $45 in 1915, $21.13 in 1914, $22.45 in 1913, $28.95 in 1912, $23.76 in 1911, and $23.58 in 1910. The average price paid for galena concentrates was $52.52 in 1915, as compared with $46.83 in 1914, $51.50 in 1913, $55.36 in 1912, and $55.75 in 1911. These prices are not average base price quotations, but are the actual average prices calculated from the quantity sold and the values reported to the United States Geological Survey by the sellers.

The prices received by the producers show that the average actual selling price of sphalerite in 1915 was $37.51 a ton more than in 1914, an increase of nearly 100 per cent, and that the corresponding increase in prices for zinc carbonate and silicate in 1915 was $23.87, a larger percentage of increase than in the price of sphalerite.

The average metal content of sphalerite concentrates derived from "soft ground" decreased from 57.9 per cent in 1914 to 57.7 per cent in 1915, and of those derived from "sheet ground" increased from 58.4 in 1914 to 59.1 per cent in 1915. The average metal content of the galena concentrates derived from "soft ground" was also more in 1915 than in 1914.

The average metal content of the galena derived from "sheet ground" declined nearly 3 per cent. This was at least partly due to the fact that sphalerite concentrates containing little or no lead were in special demand and brought much higher base prices, so that it was profitable to favor the recovery of zinc concentrates at the expense of the galena.

Briefly stated, it was good mill and table practice to make clean zinc concentrates, which could be sold for more than double the price of the galena, even when the lead content of the galena was lowered 3 or 4 per cent.

The recovery of sphalerite and galena concentrates from "sheet ground" was approximately the same for the years 1910, 1911, 1912, 1913, and 1914, indicating clearly that about 2.6 per cent of concentrates is what may be expected as the approximate recovery for a

term of years from this class of deposits when sphalerite concentrates prices ranged from $40 to $50 a ton. With an average price of nearly $79 a ton there were large profits in mining "sheet ground" containing 2 per cent in concentrates and in a number of cases considerably less than 2 per cent. Miners of "sheet ground" took advantage of the unusual conditions to treat increased quantities of thin "dirt," as shown by the 1915 average recovery of concentrates from this character of ground, which declined from 2.67 per cent in 1914 to 2.25 per cent in 1915.

The average recovery of concentrates from "soft ground" decreased from 4.61 per cent in 1914 to 4.20 per cent in 1915. The decrease in the average recovery of lead concentrates from the "dirt" treated was especially notable, as it was 0.16 per cent less than in 1914. There were less "soft ground" mines producing large yields of "cog" or free lead.

The total ore or "dirt" treated increased from 6,774,000 tons in 1914 to 10,505,900 tons in 1915. The ore treated from "sheet ground" was 6,501,000 tons, an increase of more than 2,900,000 tons, and that from "soft ground" was 4,004,900 tons, an increase of about 820,000 tons. This shows that the output of ore or "dirt" from the operations in "sheet ground" increased more than three times that from the "soft ground."

In 1915 the sphalerite concentrates derived from "sheet ground" mines amounted to 124,067 tons, and the galena concentrates to 21,658 tons. In 1915 "soft ground" mines yielded 117,001 tons of sphalerite, 12,590 tons of galena, and all of the lead carbonate, zinc silicate, and zinc carbonate concentrates. The production of sphalerite concentrates from "sheet ground" increased 43,839 tons, and that of galena 5,790 tons. The increase of sphalerite from "soft ground" was only 7,464 tons, and there was a decrease in the quantity of galena produced amounting to 2,574 tons. It must not be assumed that the small increase from "soft ground" was due to lack of prospecting or active working. It was because very few of the new mines were large producers and because there were fewer mines that could be quickly brought to a productive basis and that had been closed in "soft ground" on account of low prices of ore.

The total value of all concentrates derived from "sheet ground" mines was $10,958,263 and from "soft ground" mines $10,432,973. This shows that the value of the production of concentrates from "soft ground" amounted to only $525,290 less than the production from "sheet ground," although the ore or "dirt" milled or otherwise treated was 2,496,000 tons less in quantity.

The Webb City-Carterville-Prosperity district, which includes many of the "sheet ground" mines, was again much the largest producer of both blende and galena concentrates in southwestern Missouri. It produced 60 per cent of the galena concentrates and more than 43 per cent of the sphalerite sold in 1915. In 1914 it produced 57 per cent of the lead and 34 per cent of the sphalerite.

The quantity of crude ore or "dirt" raised is a better indication of the extent of mining activity than the production of concentrates, for the "sheet ground" ore is of lower average tenor than the "soft ground" ore. The leading position of the district is more adequately shown by the fact that the estimated quantity of ore mined in the

Webb City-Prosperity district in 1915 was about 4,985,100 tons, or nearly 48 per cent of the total crude ore raised in southwestern Missouri, and that the output in 1915 was about 2,000,000 tons more than in 1914.

Joplin, the second most productive district in 1915, showed an increase in galena concentrates of about 1,600 tons, in zinc carbonate and silicate of 1,400 tons, and in blende concentrates of 12,600 tons. About 153,000 tons of the blende concentrates out of a total production of 241,068 tons, and about 77 per cent of the galena concentrates, were shipped from the two districts.

The Duenweg-Porto Rico district, by reason of its large yield of high-grade sphalerite concentrates, advanced from fourth place in 1914 to third place in 1915. Its yield of sphalerite was 8,253 tons greater than in 1914 and that of zinc silicate increased 1,300 tons. The Alba-Neck City district, with a production very much less in 1915 than it was in 1914, was fourth in value of production. The Oronogo district output increased in value and was nearly equal to that of Alba-Neck City. Granby district was sixth, and Zincite-Klondike seventh, with an increase of about $315,000 in value of output.

The other districts which showed a largely increased yield of zinc concentrates were Wentworth, Sarcoxie-Reeds, and Aurora, but there was a decreased production in the Carl Junction, Cave Springs, Carthage, Sherwood-Thoms Station, and Spring City districts.

Many of the details of mine development, descriptions of the older concentration plants, and other data, have been given in previous reports, which can be had upon request. The more important developments during 1915 are described under the various district reviews.

REVIEW BY DISTRICTS.

Alba-Neck City district.—The shipments of sphalerite from this district in 1915 decreased about 9,500 tons, those of lead ore about 170 tons, and those of zinc silicate 500 tons. The total value of all concentrates sold was about $1,151,784, or $76,000 more than the value in 1914, when prices were much lower. The mines in the vicinity of Alba and Purcell produced a larger part of the yield than they did in 1914, and the decreased output was mainly due to a smaller output from several mines in Neck City and from all the mines northwest of Neck City.

The Century mine, though worked out by the middle of the year, was the largest shipper. Mines on the Reliance land made it the most productive property. Of these leases, that of Longacre & Chapman, subleased to the R. A. Mining Co., had the largest output. The mine caved in June; but a new shaft was sunk and work was resumed under a new lease direct to the present operators. The Cuckleburr Mining Co., on Reliance land, has a 250-ton concentrating plant, which recovered a large yield of high-grade sphalerite. The ore was mined at the 200-foot level and two shafts were used for hoisting the "dirt." Other producers on Reliance land were S. L. Bradley (now the Galena Boosters' Mining Co.), Jessie Milling Co., and Greene & Co.

The production from leases on lands of the Davidson-Joplin Mining Co. was much larger than in 1914. The following four concentrating

plants are on this land: Water Oak Mining Co., 200 tons; Sunflower Zinc Co., 150 tons; Battle Axe Mining Co., 100 tons; Teddy R. Milling Co., 100 tons.

The yield of concentrates from the Quick Seven lease of the Richardson land, northwest of Neck City, was considerably less than in recent years, but nevertheless the production was a most substantial one. The Little Mary mine on the Weaver land, adjoining the Quick Seven, was under lease to the Trigger Mining Co. The mine is on the banks of Spring River and was flooded by the high waters in September, or the output would have been much larger.

The Cliffwood, the most northwesterly mine in the district, was under lease to the Purcell Mining Co., which shipped a large quantity of high-grade sphalerite. The ore treated was obtained through two shafts 165 feet in depth and two concentrating plants were operated.

The production from Penn Zinc Co.'s land was three times as much as in 1914. Nearly all the output came from the Lucky Tiger mine, which was sold in November by G. L. Cole to interests represented by H. R. Trenholm. The new owners of the Luck Tiger also bought the Black Hawk mine on Calumet Zinc Co.'s land, on which a 250-ton concentrating plant had been erected. The mill was completed late in 1915 and the production was not large. The Batesville Mining Co. on the Lanyon land, after successfully operating its property for several months, sold its lease and equipment to the Toledo-Joplin Mining Co.

Other producing properties in the Alba-Neck City camp were the P. & N. Mining Co. on the Fox land, Jones & Co. on the Stewart land, the Silver Spoon Mining Co. on the Hill lease of the Kane & Reece land, and the Jumbo Mining Co. from tailings on the Sponable land. The shaft on the Silver Spoon mine was sunk from 153 to 165 feet. The ore mined in 1915 came from the 153-foot level and was treated by means of hand jigs. Drilling on the west side of the shaft is said to have shown "sheet ground" at the 200-foot level.

Ash Grove-Everton district.—The mining in this vicinity is all shallow, none of the workings exceeding 80 feet in depth. The ore is raised by means of horse whims and cleaned on hand jigs. Most of the lead and the zinc silicate from the Ash Grove section was mined on the Duncan land in Boone Township by the Ash Grove Mining Co. and other lessees and shipped by E. A. Hurt. The zinc carbonate and silicate produced in the Everton camp was the output of small lessees near Corry.

The high prices paid for zinc silicate resulted in many small shafts being sunk and in the rapid increase in the number of mines, until at the end of the year the output of silicate was larger than in most of the southwestern districts.

The Ash Grove Mining Co. did the deepest mining in the district. Two shafts were used to obtain ore from levels between 75 and 80 feet. This ore was concentrated by means of hand jigs and the construction of a 100-ton mill was commenced.

Aurora district.—The production of lead concentrates of this district in 1915 was five times as large as in 1914. The output of zinc silicate and carbonate increased 1,839 tons and that of sphalerite increased 646 tons. A large part of the output was made by lessees working shallow ground, the crude ore or "dirt" being treated at cus-

tom mills or sold in the rough. Much of the mining was on a small scale, though there was a distinct revival in the working of ground at the lower levels. The lessees of the United Zinc Co. produced the largest quantity of zinc silicate, nearly all of which was obtained from levels above 30 feet and sold to chatting plants. The Scottish Mining Co. opened the deep ground at the old No. 1 mine and built a 150-ton plant, which, however, was not in operation until 1916. The old mine of the No. 4 Drill Co. on the C. W. Tooker land was unwatered and the 150-ton mill was rebuilt by a new company of the same name. The ore treated at this property came from the 230-foot level.

The largest producer of sphalerite was the Missouri Hydraulic Co. This company and its lessees on the Jones and Federal lands had a good output of both sphalerite and zinc silicate. The sphalerite ore mined at a depth of about 100 feet was milled at the 100-ton mill of the first lessees; the zinc silicate ore was sold in the rough. The small mill owned by the Goat Mining & Development Co. on the Stewart land was repaired and a good recovery of zinc silicate was made.

A considerable portion of the zinc silicate from the Aurora district, in addition to a small quantity of sphalerite and galena concentrates, was shipped by C. C. Plank, who controls or manages the Cleveland Aurora Mineral Land Co., Carr & McNatt, Midland Mining Co., Milton Mining Co., and Aurora Sludge Mill Co.

The producers on the Black land were Murray & Stewart and Hudson & Co., those on the Duckworth land were Thos. Murphy and Duckworth & Ryker, and those on the Kentucky Mining Co. land were Gover & Co., Ward & Co., and Morris & Co. There were a number of small producers on the Decatur Lead & Zinc Co.'s land and the Sphalerite Mining Co.'s land, leased to E. K. Johnson.

Two shafts were in operation at the old Louisville mine, which is equipped with a 100-ton mill. Development was hampered by the excessive quantity of water in the workings. Some ore was milled and a new turbine pump was installed.

After an active drilling campaign the Red Wasp Mining Co. sunk a 158-foot shaft on the Flournoy land. A new 150-ton mill was completed and operated in December, but no shipments of ore were made. According to the owners of the property, it will produce a large quantity of sphalerite in 1916.

Carl Junction district.—The production of sphalerite in this district continued to decline. The output in 1915 was a little more than one-third that of 1914 and the amount of development done was not comparable with that in other districts. A considerable part of the production in 1915 was that of the Dallas Mining Co. on the Smith lease of the Avondale land. The Dallas Mining Co. opened up the "Little Bess" and erected a 200-ton mill, but the ground was not opened sufficiently in 1915 to supply any large quantity of ore. The V. & P. Mining Co. operated the Ishpeming land and the United Lehigh mill for a short time, then pumping was discontinued and the mill will be removed to Badger-Peacock. Some lead or zinc concentrates were produced by the Hayes and Gilmore leases on the Hall lease, the Shotgun Mining Co. on the Anderson land, and by lessees on the Nilson and the Isherwood lands. The pulling of the pumps at the old United Lehigh mine caused nearly all the small lessees on adjoining lands to abandon their workings.

Carthage district.—Reports from this district showed that the production of lead concentrates decreased 10 tons and that of sphalerite decreased 736 tons in 1915, as compared with 1914. The production of zinc silicate increased from 65 tons in 1914 to 370 tons in 1915.

The old Hermosa mine on the Amsden land, operated by the Coahuila Lead & Zinc Co., was the only large producer of sphalerite, and most of the zinc silicate was mined by the Princeton Mining Co. on the Magnet land, 4½ miles east of Carthage. The Amsden lease was taken over by the Coahuila in May, 1915, and the mill was operated steadily the remainder of the year. The Princeton Mining Co. had two shafts in ore at the 165 and 172-foot levels. A new 150-ton mill was built and was in operation in September. The production of both sphalerite and zinc silicate was satisfactory to the lessees, who report that the mine will yield a large production in 1916. The G. M. Mining Co. on the Henrietta Glenn land erected a 250-ton mill which recovered sphalerite concentrates from ore mined at three shafts. The Porter & Myers land in the city of Carthage was leased to the Carthage Mining Co. and by it subleased to the Quick Four Mining Co. which opened the ground and recovered a considerable quantity of ore. A small quantity of sphalerite and a good output of zinc silicate was obtained from the Pleasant Valley lease of Henry Weymann, which was subleased to the Goode Co. The production of zinc silicate from the Cobaugh lease of the Bergner land was much less than usual.

More development work was done than for several years and preparations were made to reopen some idle mines and to erect tailing mills. The new work should result in a larger production than the district has had for several years.

Cave Springs district.—The production of lead and zinc concentrates in the district was less in 1915 than in 1914. The Hartford Mining Co. purchased the lease and mill, formerly owned by the Big Brownie Mining Co., on the Schmidt & Schemerhorn land. The mill was rebuilt, its capacity increased from 150 to 300 tons, and electric power was substituted for steam power. The largest production came from the Schmidt & Schemerhorn land and included that of the White Oak Mining Co., the Hartford Mining Co., and their sublessees. The Carter land was mined by the Cave Springs Lead & Zinc Co., which sold a large quantity of sphalerite having a zinc content of 61 per cent. Lessees of the Playter Bros. Mining & Realty Co. and of McCullough & Murdock, both on the Hartley land, mined ore bodies lying at depths ranging from 60 to 100 feet. This ore was treated at custom mills or by means of hand jigs, as there were no concentrating plants on the land.

Duenweg-Porto Rico district.—This district is one which contains the second largest number of "sheet ground" mines in the Joplin region, and it was one of the most active in 1915. The district production of sphalerite increased from 19,526 tons in 1914 to 27,789 tons in 1915, and that of zinc silicate from 169 tons in 1914 to 1,507 tons in 1915. The output of galena concentrates was about the same in each year. The total value received in 1915 for lead and zinc concentrates sold was $2,526,310, against $910,300 in 1915. The whole increase in yield of sphalerite was due to the mining of "sheet ground," for the output from mines of this character increased from 1,558 tons of galena and 13,381 tons of sphalerite in 1914, to 2,082 tons of galena and 22,352 tons of sphalerite in 1915. The "sheet

ground" mines produced 67 per cent of the galena and 80 per cent of the sphalerite concentrates, which was a much larger proportion than in 1914. The increase in the output of zinc silicate in 1915 was due to the reopening of the mines on the Hall land.

The Coahuila Lead & Zinc Co. was again the largest single producer in the district, though the combined output from the mines on the Boston Duenweg land exceeded that of the Coahuila. Nearly 250,000 tons of ore were treated at the Coahuila mill, and the zinc concentrates sold had an average zinc content of 59.5 per cent. The American Zinc, Lead & Smelting Co. unwatered the Vogey mine at Porto Rico and mined ore from the old workings and from the adjoining land of Dougherty & Lyons. No shaft was sunk on the last-named land and all the ore was hoisted at the Vogey shaft. The Thanksgiving mine on the Brown land was acquired by the Fidelity Mining Co. The concentrating plant was remodeled and the mine unwatered during the summer. Ore from "sheet ground," lying at the 200-foot level, was hoisted through two shafts. The old Trinity mine, also adjoining the Vogey, which had been idle for three years, was unwatered and the Chapel mill remodeled and connected with the north shaft by a 700-foot tramway. Mining was done at the 186-foot level, mostly in "sheet ground."

The Van Dorser land lying east of the Vogey was purchased by the Raymond Mining Co. The production made by the lessees was large after the ground was opened. The Barnett Mining Co. leased the Porto Rico mine and 175-ton mill, built a new sludge plant, and mined "sheet ground" through a 180-foot shaft. It was the largest producer on the Raymond land and the first lease in operation. The Marjorie Stewart Mining Co. also mined "sheet ground" after building a 300-ton mill which was not operated until the latter part of 1915. The National Lead & Zinc Co. built a 100-ton mill adjoining that of the Marjorie Stewart, in which ore from "soft ground" lying at the 80 to 120 foot levels was treated. The small mill of the Charter Oak Mining Co., south of the Marjorie Stewart mill, was run on custom ore and tailings. The Henrietta Cosgrove land, south of Porto Rico, was leased by the Franklin Mining Co., which made a steady production of sphalerite from "sheet ground" opened in the fall of 1915. The producing leases on the Boston Duenweg land were the Wilson, the Baltic, and the Vinegar Hill. The Wilson mine had its usual large production of high-grade concentrates, and the Baltic, formerly the O. F. & L. mine, made a large output from "semisheet ground." The owners of this property paid a large sum of money for the lease and equipment, but the ore mined was unusually rich and the property was one of the most profitable in the Joplin district. The Wilson mine has since been purchased by the Onamena Mining Co., which operated the old Brooklyn mine on the Hill land west of the Baltic, in 1915. Tailings were run at the 300-ton plant at the Brooklyn mine while the "sheet ground" was being opened. The Onamena Mining Co. also acquired the old M. & B. and King William mines on the Chase land, which are to be equipped with a 300-ton mill in 1916.

The American Beauty mine on the Colclasure land, which had been idle for many years, was leased by the St. Regis Mining Co. The mine was pumped out and one of the most complete concentrating plants and other surface equipment in the district were completed in

November. This mill, which has an estimated capacity of 1,000 tons a day, made a large quantity of concentrates in the two months in 1915 in which it was operated.

The Scott Mining Co. also built a large concentrating plant in 1915. The mine and mill operated by this company are on the Ground & Erwin land lying northwest of the Baltic and Onamena mines. One shaft near the mill was used in 1915 and another one was being sunk 560 feet east of the mill. The mill recovery of concentrates from dirt treated in 1915 is stated to have averaged about 4.25 per cent.

The Gopher Mining Co. operated the Lincoln mine and mill until August 21, 1915, when it was purchased by the Athletic Mining & Smelting Co. The new owners added 2 new boilers, 2 motors, 19 sludge and slime tables, two 40-foot Dorr thickeners, and an air compressor to the equipment of the concentrating plant, which now has a capacity for the treatment of 1,000 tons a day. New leases were also acquired on the Wolfheart and Maple Leaf tracts of the Jasper Royalty Co.'s land.

The most productive leaseholds on which "soft ground" was mined in 1915 were those on the Chew land, and of these the What Cheer mine had the largest output. The 300-ton mill at this mine was run steadily all the year. In December a very promising ore body was opened on the 155-foot level by means of an upraise in the roof of the lower workings at 190 feet. The Douglas & Anderson lease was worked by several lessees and the new 200-ton mill on the ground was used to treat tailings. The Owosso Development Co. opened a new mine and built a fully equipped concentrating plant having a capacity of 200 tons. This plant was not completed until late in 1915, so that the output was comparatively small. The only other large mine on the Chew land was the Melrose mine owned by Hugh Correll.

The Davis Mining Co.'s production of zinc silicate from the Corl land was small, but a new shaft was sunk and the building of a 150-ton concentrating plant was commenced.

Not only was there an increased yield of concentrates from the Crown Crest land, but the development work accomplished in 1915 will result in a much greater output in 1916. New mills of 150 tons capacity were built by the Crown Point Mining Co. and the Yellow Jacket Mining Co., and there were several other lessees working on the land. The Kersey Mining Co. developed a mine on the Aylor lease of the Largent land and built a 150-ton mill.

One of the few good bodies of lead ore opened in 1915 was that of the Frerer Mining Co. at the 160-foot level. No shipments of galena were made until January, 1916.

Ninety per cent of the zinc silicate shipped from the district in 1915 came from mines on the Hall land. There were 3 shafts and 2 concentrating plants in operation. A new mill was built by Bell & Co. on the Bartley land and a 135-foot shaft sunk after the lease had been thoroughly drilled. There were no new developments on the Walker land from which lessees mined a good production of galena and sphalerite.

Other lands and leases which produced lead or zinc concentrates in 1915 or upon which development was done were as follows: Acme Lead & Zinc Co., Rusk Sludge Co., and W. A. Hughes on the December tract; lessees on the J. W. Burch land; Sturm, Roberts & Smith, British Mining Co. on the Carrick land; S. C. Betts on the Kirk

land; Malloy & Cameron, Jos. Aldrich on the Mussellman land; C. A. Byrd, Rideau Mining Co., Royalty Land & Mining Co., the Purciller Mining Co. on the Stevison Rogers land; the Sadtler land; R. A. Moneyham on the Corbin land; and Hackmeister, Sneed & Co. on the Henry Weyman land at Diamond.

Granby district.—The output of sphalerite concentrates in this district in 1914 was more by 2,775 tons and that of lead concentrates less by 137 tons, than in 1914. The production of zinc carbonate and silicate concentrates increased only 535 tons in quantity, but the value in 1915 was double that of 1914. More than 45 per cent of the output of zinc carbonate and silicate concentrates from the Joplin region came from the Granby district. An increased quantity of ore was derived from the J. B. Davis and the St. Paul Mining Co.'s lands, but most of the producing territory belongs to the Granby Mining & Smelting Co. The total production was large, the relative quantities of zinc silicate, zinc blende, galena, and lead carbonate being in the order named. Much of the mining by small companies and by individuals is in shallow workings that yield galena and zinc silicate ore. The larger producing lessees on the Granby lands were the Broken Hill Co., Margaret D. Mining Co., Golden Rule Mining Co., Jack Snipe Mining Co., Little Boss Mining Co., Katy Mining & Milling Co., J. R. Underwood Mining Co., Billiken Mining Co., Granby Sludge Co., Automobile Mining Co., Little Boss Brotherhood Mining Co., Hash Richardson & Co., Fortune Teller Mining Co., Local Mining Co., Pierson-Cook Mining Co., Trilby Mining Co., E. T. Perkins, O. L. Goade, S. P. Swindell, Pocahontas Mining Co., T. Bennett, Courtney & Co., and Waterworks Mining Co. The depth of mining varied from very shallow openings to 215 feet, and 10 concentrating plants were operated.

The 200-ton custom concentrating plant of the Granby Mining & Smelting Co. is so squipped that it can be used to concentrate either blende or calamine ore. Many of the lessees on this land have no concentrating equipment and a large quantity of ore is treated at custom mills or sold in the rough, so that almost one-third of the blende and silicate concentrates shipped were recovered at the Granby custom plant. The new mills constructed in 1915 were the Hurst-Golden Rule sludge plant, Spud-Mascot sludge plant, Margaret D. 200-ton mill, Fortune Teller mill, and Klondike mill.

The Dick Stapp, Katy, Mascot, and Homestake mines were operated by the J. R. Underwood Mining Co. At the Dick Stapp ore was mined at levels between 75 and 149 feet, at the Katy between 75 and 90 feet, and at the Mascot between 160 and 225 feet. Electric power was substituted for steam power at the Mascot mill and a separate sludge plant containing 6 tables was added to the equipment.

The Granby Mining & Smelting Co. continued the development of the ore body located at the 180-foot level of the Klondike mine. Two shafts were in ore and drifts were being driven to connect them. The ore faces are 30 to 40 feet high and the dirt milled yielded between 4 and 5 per cent in concentrates. The workings were not opened early enough to assure the largest possible production in 1915, but development was sufficiently advanced to show that the operators had a very large mine. The concentrating plant of 1,000 tons daily capacity is driven by electric power and the adjoining sludge plant is large and well equipped.

Joplin district.—The increase in output of both lead and zinc concentrates in this district was, with the exception of that of Webb City, greater than in any other district in the Joplin region and the number of mines, large and small, exceeded those of any two other districts. It was the central point around which all the expansion of mining activity sprang up. Some camps in the district were neglected, but in general transfers of mining lands and leaseholds, construction of mills, and the moving of old plants to new mines prevailed in every section. There were numerous old and idle mills in the vicinity, many of which were obsolete or in a bad state of repair. All of these were speedily purchased by operators and so many new plants were contracted for that at certain periods it was difficult to fill orders for machinery without considerable delay.

The mines near Thoms Station and other camps are locally classed as belonging to the Joplin district and their output is included with that of Joplin, and in considering the relative output of Joplin camp (as given in the table of production), compared with that of the eastern and the extreme western districts of the Joplin region, the output of these camps must be taken into consideration.

The district easily retained its place as the second largest producer in southwestern Missouri. The sales of concentrates in 1915 were as follows: Galena, 6,085 tons, valued at $325,731; lead carbonate, 20 tons, valued at $392; zinc blende, 49,074 tons, valued at $3,825,971; zinc carbonate and silicate, 3,460 tons, valued at $149,092. As compared with 1914 the sales in 1915 of lead concentrates increased 1,605 tons, of zinc silicate and carbonate 1,380 tons, of zinc blende 12,637 tons, and the total value of all concentrates sold increased $2,651,985, or 161 per cent. About 60 per cent of the zinc blende and 66 per cent of the galena concentrates were recovered from ore mined in "soft" ground. This is 5 per cent less of the zinc concentrates and 23 per cent less of the galena concentrates than the corresponding recoveries in 1914 from "soft ground." This decrease reflects the importance of the output of the "sheet ground" in the west Joplin camp, which will be even more notable in 1916. Eight new concentrating plants were erected or rebuilt in this section of the district and notwithstanding that many of the mills were completed late in the year the production from "sheet ground" increased from 600 tons of galena and 12,784 tons of spahlerite in 1914 to 2,070 tons of galena and 19,782 tons of sphalerite in 1915.

The largest producer from "sheet ground" was the A. W. C. Mining Co., which continued to make a large output from Mine No. 2 on the Banner Investment Co.'s land and Mines Nos. 1 and 3 on the Luke & Ash land. All three mines are equipped with large concentrating plants, one of which, on the Luke & Ash land, was erected in 1915. Two shafts were used to hoist ore from the 190-foot level. The Poland Tailing Co. used a 200-ton plant to rerun the tailings from the old Hero mine on Banner land. An experimental flotation plant was built at this tailing mill. The results are stated to have been encouraging but not definitely successful.

The Geronimo mine of the Underwriters' Land Co., and the Otis mine on Expansion land now owned by the Consumers' Mining Co., were steadily worked, and the outputs compared favorably in quantity and quality with other mines in the vicinity. The Liberty Bell

mine on Expansion land, adjoining the Otis mine, increased its output by installing a separate sludge plant having a capacity of 100 tons. The old Kittemac lease on the Deering land was acquired by the S. Y. Ramage Mining Co. and a 400-ton mill with an independent sludge plant containing 10 tables was finished in October. The plant treated ore raised from the 130-foot and 170-foot levels by means of three shafts. The Metzler land produced a good output of concentrates from "sheet" and "soft ground." Two mills were operated on the land; that of the Gibson Mining Co. treated ore from "sheet ground" and that from the Once More Mining Co. treated ore from "soft ground."

Not only was the production from the Lambert land considerably larger than in 1914, but in addition the development accomplished and new leases granted should result in another large increase in 1916. Most of the production in 1915 was that of O. R. Symmes, who mined "sheet ground"; the output was milled at a 250-ton plant. The production of the Dick Turpin Mining Co.'s lease was small, for the 300-ton mill was not completed until December. The ground was opened by two shafts and "sheet ground" was mined. The Osceola mill No. 3, on the same land, was used to treat tailings, and a new mill of large capacity is under construction which is to be used to concentrate ore from another lease on the same land. The old Falls City mine on the Higgins land was operated by the La Nora B. Mining Co. and by their successors, the Oklahoma Consolidated Lead & Zinc Co. The Martha Ball lease, which is also located on the Higgins land, was transferred to the Bradley Lead & Zinc Co. and is now owned by the Spiral Lead & Zinc Co.

The most southwesterly "sheet-ground" mines in the district are the Handford and Duquesne on Mattes Bros. land. Both mines had a large production and additions were made to the mining equipment. The old Muskingum mine and mill was purchased by the Coyote Mining Co. which practically rebuilt the mill and sunk another shaft to the 180-foot level.

The Sparkler Mining Co. opened a new mine on the Taylor & Glover land and erected a completely equipped 300-ton mill, which was started in October. The old Samson mine was reopened by the Grower Mining Co. and a considerable quantity of concentrates were shipped. The producers of galena, sphalerite, and zinc silicate concentrates from disseminated ore bodies and from shallow ground were so numerous that only brief mention can be made of a few of the largest producers, of the new mines opened, and of the lands on which new work was done or new concentrating plants or additional equipment installed. The largest output of galena was from lands of the Connor Investment Co., Continental Zinc Co., Granby Mining & Smelting Co., Rex Mining & Smelting Co., and the Paul estate. Most of the zinc silicate was mined by lessees on land owned by W. L. Butts, Connor Investment Co. (at Central City), No Name Mining Co., German American Mining Co., Home Land & Loan Co., Missouri Lead & Zinc Co., Saginaw Land & Mining Co., Rose Land & Mining Co., and L. F. Williams. Productions of sphalerite each amounting to more than 2,000 tons were obtained from leases on Granby, Continental, Connor, Dirigo, and St. Louis Joplin lands. Properties which had a good output but less than those already named were

the American Zinc, Lead & Smelting Co., Alhambra Mining Co., G. E. Quimby, C. M. Sheldon Mining Co., lessees of the General Lead & Zinc Co., Lone Elm Development & Mining Co. (Picher land), Empire Zinc Co., Home Land & Loan Co., Montgomery Lead & Zinc Co., Rex Mining & Smelting Co., United Zinc Cos., Pittsburg-Joplin Mining Co., H. & F. Mining Co., P. L. Swartz, Shellino Mining Co., Douglas & Anderson, Cooper & Peters, and Hillside Mining Co.

Small shipments of lead or zinc concentrates were made by many operators, including the following: Emily G. Mining Co., Armil Sludge Co., St. Joe Mining Co., Eldorado Mining Co., Inter City Mining Co., and lessees of the Paoma Mining Co., Ohio Land Co., Roaring Springs Mining Co., J. B. Robb, Shoal Creek Mining Co., Ohio Missouri Prospecting Co., E. Thompson, Woodburn Mining Co., and H. H. Gregg.

Amongst the transfers of mining lands or leases, new mines opened, or new concentrating plants erected at mines other than in "sheet ground," were the following: The Emperor mine on "American" land at Central City, which has become a large producer; the Armil Sludge & Tailing Co., which built a new plant on the Rex land; the Grand Tower Mining Co., which opened a new mine and contracted for a 150-ton mill on the James Campbell land; the St. Joe Mining Co., which sunk a new shaft and completed a new 200-ton mill at Chitwood; a new 150-ton tailing mill on the Continental land; and a new mine developed and a 150-ton concentrating plant on the Quimby lease of the Cox land operated by the Oak Orchard Mining Co. Many new leases were given on the Empire Zinc Co. lands and a new 150-ton mill was under construction for the Blendville Mining & Leasing Co. The Stickney land was leased to the Florence Mining Co. and a contract was given for a new mill to be completed in March, 1916. A complete 200-ton plant operated by electric power was built by the Once More Mining Co. on the Metzler land in the west Joplin section.

The Little John Mining Co. sunk two shafts on a lease on the Rex land and installed a complete surface equipment, including a 125-ton mill. This plant was in operation for only a short time in 1915. Part of the Robb land was leased to the Old Friends Zinc Mining Co. and a 150-ton mill was under construction. The new 200-ton plants erected on St. Louis-Joplin land were those of the Swan Machinery Co. and the Bradley Lead & Zinc Co. The Bradley mine developed a very rich ore body and made a large production before it was sold to the Ethel Gray Mining Co., the present owner. The 200-ton plant of the Peruvian Mining Co. on the Taylor land was completed in December, so that only a nominal production was made. The old mill on the I Know lease of C. M. Sheldon on the Taylor land was rebuilt and operated late in the year.

Oronogo district.—The production of the Oronogo district increased from 1,670 tons of galena concentrates and 9,472 tons of sphalerite concentrates in 1914 to 2,135 tons of galena and 12,834 tons of sphalerite in 1915. This increase of about 25 per cent was caused by the larger output of the Oronogo Mutual Mining Co. Most of the producing territory in the district has been owned for many years by the Granby Mining & Smelting Co. and the production from the Oronogo Circle mine on that land has been, prior to 1915, several times larger than the combined yield from other mines in the district. In 1915,

however, the output of the Oronogo Circle mine, the Morning Star Sludge plant, and other leases on Granby land was slightly more than half the production of the district. Three shafts were in operation and ore was mined from the 190-foot and 225-foot levels and treated in the concentrating plant which has a capacity of 1,000 tons in 24 hours.

The Oronogo Mutual mine and mill, which was fully described in the district review for 1914 was operated steadily throughout the year. It was one of the largest and most profitable properties in the Joplin region. Considerable drilling was done in the vicinity of Oronogo, including among other lands the Poundstone, Patton, Stevison, and Carter.

Reeds-Sarcoxie district.—The production of the district in 1915 was 2,002 tons of sphalerite and 251 tons of zinc silicate, as against 941 tons of sphalerite and 185 tons of zinc silicate in 1914. The value of these concentrates was about $120,000 more than in 1914. Almost all the zinc silicate was produced by lessees on the H. B. Boyd land and the sphalerite was derived from the J. W. Boyd land at Sarcoxie and the Cornell land at Reeds. The Cameron mine on the Boyd land was operated during the early part of 1915 by the Lower Level Mining Co. and later by the Flannery Zinc Co. Considerable underground development was done by the last-named lessees and new jigs and hoppers were added to the surface plant. Some ground was mined at the 300-foot level, but this was discontinued and the extraction of ore was confined to the 200-foot level. Two shafts were used in 1915 and two other shafts were being sunk to the ore body now mined. The old Ravenswood mine was reopened in June by the U. S. Smelting Co., and the concentrating plant which now has a capacity of 750 tons daily was entirely reconstructed. There are three shafts at the mine and the ore is taken from about the 250-foot level. The mill was in operation less than three months and the output was large though the "dirt" was low grade.

Thoms Station-Sherwood district.—In 1915 this district produced 291 tons of lead concentrates and 4,723 tons of blende concentrates less than in 1914 and dropped from seventh to eighth place among southwestern Missouri districts. The output of lead concentrates in 1915 was 555 tons, valued at $31,863, and that of zinc blende concentrates was 4,813 tons, valued at $349,846. There were quite a number of small mines developed in 1915 and ore was recovered by means of hand jigs. The district has been noted for its rich but small ore bodies. The large reduction of output was not due so much to the number of mines worked but to the comparatively small yield from such mines.

About one-half of the total yield of sphalerite was the product of the Pocatella mine on the Sheridan Adams Royalty Syndicate land and the Olive Cherokee mine on the Murphy land. Comparatively good outputs of sphalerite were recovered by means of hand jigs at the Silver Dick mine on the Alamo land, by lessees of the Wyatt Mining Co. on the Dixon land, and by lessees of the Tuckahoe Mining Co.

The heavy rains flooded the workings at the Napoleon mine twice in six months, causing heavy damage and a much decreased production. Many new leases were given on the Mexico Joplin land but

only two mills were operated and the output was comparatively small compared with that of previous years.

One 150-ton mill, that at the Pocatella mine, was operated on the Sheridan Adams Royalty Co.'s land, but there were many small leases developed. A number of new shafts were sunk and five hand jig plants were making concentrates. The combined output by the Pocatella mill and these hand jigs resulted in a production larger than that from any other land in the district.

Small yields of lead or zinc concentrates were also made by lessees of the Catherine Mining & Royalty Co., General Lead & Zinc Co., S. E. Spencer, and the Frisco Mining Co.

Spring City-Beef Branch district.—The production of galena concentrates in this district decreased 848 tons in 1915 and the total value of the galena concentrates sold was $34,070 less than in 1914. The output of lead carbonate was small, as has been usual in recent years. The output of blende or mixed blende and zinc silicate concentrates was 1,617 tons less than in 1914, but the quantity of zinc silicate shipped increased 991 tons. The value of the zinc concentrates, however, increased $118,155. Only one new concentrating plant was erected during the year, though quite a number of hand-jig equipments were provided by the small operators.

The smaller yield of galena and of sphalerite was due mainly to the closing down of the Delta mine on the McCown land, though the production by the lessees on the J. W. Allen land was smaller than usual. The production of all classes of ore from the St. Paul Mining Co.'s land increased considerably. Two shafts were used on this land in 1915 and a large quantity of concentrates was made by hand jigging.

The Inca Mining Co. purchased the Ford mine near the old Aladdin and milled some very rich ore. The deepest mining done in the district was by the Onondaga Mining Co. on land owned in fee. The shaft at this mine is 190 feet in depth and the mill has a capacity of 200 tons.

Sphalerite concentrates were also produced at the 100-ton plant of the White Oak Mining Co. on the Sulphide Corporation land. This mine was shut down early in October, 1915.

Lessees on the Zeta Land & Investment Co.'s land shipped the various kinds of concentrates. The principal shippers were the H. & H. Mining Co. and White & Co. The only new concentrating plant under construction in the district was that at the old Mary E. mine on the Haines land. At this mine considerable development was done after it was unwatered.

Lead or zinc concentrates aggregating about 500 tons were also shipped by various lessees on the Armil, Bales, Georgia, Hoge, Leake, Peck, and Weymann lands.

Springfield district.—The production of galena and of sphalerite in this district in 1915 was slightly less than in 1914, though the value increased. The Bray mine, which has been a large producer, was not operated in 1915 and work was not resumed until early in 1916. The Clark Mining Co.'s lease on the Fallin Bros. land was the largest producer. The ore deposits at this property, as in other mines on Pierson Creek, are in channels mixed with gumbo. The ore mined at the Clark mine was taken from the 145-foot level. The con-

centrating plant, which has a capacity of 100 tons, was improved by the addition of a sludge plant. Core drilling in advance of the drifts was found to be of great assistance in locating the ore.

The development at the Gem mine on the Parker land was continued and new pumps, boilers, and tramways were installed. The 100-ton mill produced some concentrates but production was hampered by floods. The mine has been purchased by the Anna M. Mining Co. The Choteau and Ingram leases were mined by A. Clas, who shipped a good output of high-grade concentrates.

C. D. Meyer & Co. leased the Tuttle land and drilled a number of holes which are said to indicate an ore body containing 10 per cent in concentrates. The shaft was sunk 145 feet and the erection of a 100-ton mill was begun. Development was also done on the Webber land by Erlinger & Becker.

The percentage of concentrates in the "dirt" is above the average recovery for the region; moreover, the zinc content of the sphalerite is between 62 and 63 per cent and carries very little iron. The galena concentrates recovered are also high grade, averaging about 82 per cent lead.

Spurgeon-Seneca district.—The total value in 1915 of the concentrates shipped from this district was $81,660, an increase of $31,707, compared with 1914, though the quantity of concentrates was no larger. Nearly all the blende concentrates shipped were produced by the Bat mine, on the Aylor land, and the Quaker and Spurgeon Tiger mines, on the Bucklin & Wills land. The other small producers were lessees working on the Buchanan, Newman, Swartz, and Blue Bird lands.

The workings at the Bat mine caved during the year, so that the output was much less than in 1914. After an idle period of some months the mine was sold to the Bradley Lead & Zinc Co.

The Spurgeon Tiger was the largest producer in the district. Two new shafts were sunk, derricks and incline tramways erected, and new boilers and tables were added to the mill equipment.

There were two 100-ton concentrating plants operated on the Bucklin & Wills land, one of which was built in 1915. Six shafts were used to hoist ore from levels varying from 60 to 100 feet in depth.

Stotts City district.—None of the mines in this district reported an output in either 1914 or 1915. The old Gundling mine, now owned by the Lawrence Land & Mining Co., is reported to have been leased in 1915 by a new company that is building a 450-ton mill. The Stott estate land was prospected in 1915, and new mills are said to be under construction on it in 1916.

McDowell and Stark City districts.—A small quantity of lead, sphalerite, and zinc silicate concentrates, having a total value of about $3,000, was shipped from these districts. The only producing mine at Stark City, in Newton County, was that of the Stark City Mining Co., on the K. D. F. Mining Co.'s land. This company opened zinc silicate ore bodies at the 65 and 90 foot levels. The production of concentrates was made in November and December by means of hand jigs. The only productive mines at McDowell, in Barry County, were the Big Chance Mining Co.'s lease on the Henderson & Stuckey land and the C. D. Meyer's lease on the Hemphill land. At the Big

Chance mine zinc silicate concentrates were recovered by using a crusher and hand jigs, and at the Meyers lease some galena and sphalerite ore was mined at the 65-foot level.

Wentworth district.—This district did not have a much larger production in 1915 than in 1914, as many of the mines reopened and equipped with concentrating plants were not completed or were operated only during the latter part of 1915. The quantity of sphalerite sold increased about 100 tons and that of zinc silicate about 450 tons. The largest reported output was that of the Smith & Hodges Mining Co., at the Jack Possum mine. The ore body mined lies at the 90-foot level and has been blocked out 600 feet in advance of the present workings by drilling. The Turkey Point Mining & Milling Co. erected a 250-ton mill to treat the old Alice Dayton tailings. Neither this mill nor the 300-ton concentrating plant of the East Hampton Mining Co. were finished in 1915.

Both blende and zinc silicate concentrates were shipped from the Cotton Tail mine on the Lang land, which was purchased by the North American Lead & Zinc Co. The new owners erected a 200-ton mill, which has been in steady operation since December, 1915.

Another new mill built was that of the D. & L. Mining Co. on the Baker land, which was completed in time to make a good output of sphalerite concentrates. There were no shipments reported from the Stinsonville section of the district, though several drilling machines were used in prospecting and a shaft was sunk by R. O. Lamson on the Ingram land.

Christian, Ozark, and Taney counties.—The production shown in the Missouri table includes that of the Arnold land in Christian County, that of the Southwestern Zinc Co. in Ozark County, and that of the Melva Mining & Milling Co. and the King Solomon Mining & Milling Co. in Taney County. All these counties are in the southwest corner of Missouri, adjoining Arkansas. The shipments of concentrates amounted to 282 tons in 1915; it was all zinc silicate, except a few tons of sphalerite shipped from the Silver Moon mine by the Melva Mining & Milling Co.

The old Alice mine near Wetherill, which had been a steady shipper of zinc silicate for many years, was not worked. The Arnold land, in Christian County, was leased to John T. Woodruff, George E. Bray, Bull Creek Mining Co., and Koener & Bilyea. The old 80-ton mill on the tract produced zinc silicate concentrates from ore taken from a 65-foot shaft. The construction of a 100-ton plant was begun on the Bray lease which was developed by means of open cuts. Considerable development was done on the land by the other lessees which should result in an increased output in 1916.

The Southwestern Zinc Co.'s property is in sec. 31, T. 23 N, R. 11 W., near Sharp in Ozark County, and the zinc silicate was shipped from West Plains. All the ore was obtained by means of open cuts; there was no mill on the property.

At the King Solomon mine, in Taney County, a new mill was building. The only shipment was a small quantity of ore sent to Joplin for treatment. The Josie B. mine near Melva was also a small producer of zinc silicate.

Zincite-Klondike district.—The mines in this district include those in the territory south of Zincite along the western border line between Missouri and Kansas and to the north of Smithfield.

The total yield of sphalerite in 1915 was 6,000 tons, valued at $164,409—more than three times the value of the output in 1914.

Many active properties were opened and some new mills were built. The increased output was from small mines, and no large producing mines, similar to the Yellow Jacket, were developed. About 50 per cent of the output of the district was derived from the Yellow Pup, Yellow Jacket, and Locke mines near Smithfield. Fare & Graham leased the Yellow Jacket, and the "dirt" mined was milled at the Aberdeen mill of Douglas & Anderson, who also did custom milling for other lessees. Notwithstanding delays occasioned by caving ground, the Yellow Pup mine was the largest producer in the district. Two shafts were used at the Locke mine, through which ore was hoisted from very soft ground at the 100-foot level. The mine was opened late in 1914 and the 100-ton mill was completed early in 1915.

The production from the land of the Belville Land & Mining Co. was double that of 1914. Six shafts were in operation and a new 100-ton tailing mill was built by Lichliter & Co. The Kathleen 75-ton mill of the Belville Mining & Custom Milling Co. and the 100-ton mill of the Nancy B. Mining Co. were mainly run on "dirt" mined by sublessees. There were no mills on the land of F. R. Brooks, A. M. Brooks, and A. B. Brooks. Thes phalerite produced by lessees was recovered by hand jigging or the "dirt" was sent to a custom mill. The old mill at the Standard Hill mine was repaired by A. J. McElhenie and used to treat tailings from the Campbell land.

The Sophia mine on the Capitalista lease was purchased by the Elsie Mining Co. and a good output was made at the 75-ton mill after it had been repaired. The only production from the Davison land was that of the Keystone Mining Co., which expended a considerable amount of money to supply new surface equipment and pumps.

The most active property near Zincite was that of J. Harry Lindemann, who purchased the Wysbrod land. The production made by lessees on this land was comparatively small but the work done will result in a large production. Three new mills were erected. That of the Lucky George Mining Co., having a capacity of 150 tons, will be used to treat ore hoisted from a 136-foot shaft. The other two mills, owned by Martin & Co. and the Big Tom Milling Co., are of 100 tons capacity and were used to treat old tailings. A new 150-ton mill was also built on the land of the Geneva Mining & Leasing Co. by the Block City Mining Co.

Most of the galena concentrates shipped from the district and a good output of sphalerite was obtained by lessees of the Big Stump Mining Co. on the Llewellen land. There were several new leases granted on the land, and a new mill was built by Rollin & Llewellen. The New England Zinc Corporation resumed work on its lease of the Edwards land and sunk a new shaft.

The 1915 Mining Co., which acquired the old Missouri Standard mine and 125-ton mill, sold sphalerite concentrates having an average zinc content of 63.5 per cent, obtaining for one shipment the highest price recorded in 1915. Two shafts were operated by this company, one of which, the Springfield shaft, was opened to the 136-foot level.

Although greatly hampered by an excessive quantity of water in its mine, the New Geronimo Lead & Zinc Co. sold a large output of high-grade sphalerite.

Other producing properties in 1915 were lessees on the lands of the Missouri Hills Zinc Co., Walnut Hollow Mining Co., Minor Graham Lead & Zinc Co., and J. R. Wingert.

Webb City-Carterville-Prosperity district.—This district includes most of the original and typical "sheet ground" territory, and the high prices paid for zinc concentrates in 1915 increased the value of the galena and sphalerite concentrates sold from $3,242,402 in 1914 to $8,849,268 in 1915. The output of the district naturally increased more rapidly than that of other districts, for there were many idle mines having large bodies of ore blocked out which could be put on a producing basis by unwatering the mine and repairing the surface equipment. Mills which had been operated single shift were worked double shift, or even continuously. Some new leases were developed, but most of the increased production came from old properties which had been producers in 1914 or prior to that year. The main features of the year for the district were the greatly increased production, the draining of mining tracts covering an area of 770 acres near Carterville, by the Zinc Corporation of Missouri, the opening of some very rich "soft ground" mines on the Connor land at Prosperity, and the increased use of thickeners, classifiers, and tables.

The average recovery of galena and blende concentrates from crude ore mined from "sheet ground" has been between 2.6 and 2.7 per cent for the last five years. It is generally believed that most mines having ore that yields between 2 and 2.5 per cent in concentrates can not be profitably operated when blende concentrates sell for less than $45 or $50 a ton. At the abnormal prices paid for sphalerite concentrates in 1915, however, "dirt" which yielded 2 per cent in concentrates was very profitable. Some of the mines milled "dirt" from "sheet ground" that averaged 1.7 or slightly less, and the average recovery of concentrates from "sheet ground" in the district in 1915 was 2.32 per cent, of which 0.41 per cent was in galena concentrates. Many of the "sheet ground" mines yield 1 ton of galena concentrates to 4 or 5 tons of sphalerite. The average low prices paid for galena induced the miners to favor the recovery of a high-grade zinc concentrate containing less than 1 per cent lead. A small proportion of sphalerite in the galena concentrates was not objectionable, so that the lead content of the galena sold was less in 1915 than in 1914.

Only a very small percentage of the district production is derived from "soft ground," and the prominence of the "sheet ground" mining is indicated by the fact that about 70 per cent of the total production of crude, "sheet-ground" ore came from this district. The recovery of galena concentrates in southwestern Missouri from ore mined in "sheet ground" was 21,658 tons, of which this district produced 17,506 tons. The quantity of zinc blende concentrates in southwestern Missouri derived from ore mined in "sheet ground" was 124,067 tons, or 51 per cent of the total zinc blende output of the entire State, and of this large quantity the "sheet ground" mined in the Webb City-Carterville-Prosperity district yielded about 81,933 tons, compared with 54,063 tons in 1914.

The total production of lead concentrates in this district in 1915 was 20,476 tons, or 3,080 tons more than in 1914, and the value increased $233,691. The production of zinc blende concentrates in

1915 was 103,923 tons, an increase of 39,834 tons as compared with the output of 1914. The total value of the concentrates sold was $8,849,268 in 1915, $3,242,402 in 1914, $4,298,544 in 1913, and $6,522,781 in 1912. The production from "soft ground" in the district showed a decrease of 716 tons of galena and an increase of 11,964 tons of sphalerite.

Lessees on the Guinn land reported the largest output of zinc concentrates in the district and the second largest production of galena. The production of sphalerite concentrates increased more than 9,000 tons and that of galena 800 tons. The capacity of the 10 concentrating plants on the land was in excess of 4,000 tons a day. The leasing companies that produced in 1915 were as follows: Electrical Lead & Zinc Mining Co., Ice Plant Mining Co., Rhea Lead & Zinc Co., Mont B. Mining Co., Cunard Mining Co., Carmean & Squires (mills 1 and 3), Media Mining Co., Hurry Up Mining Co., and Holmes Milling Co.

Ore from "sheet ground" was treated at all the plants except that of the Holmes Milling Co. One of the largest and best-equipped mills in the district was erected at the old Home Run mine by the Media Mining Co. A new double-compartment mill shaft was sunk and skips were used instead of the usual iron tubs to hoist the "dirt." A separate sludge plant containing 11 tables and concrete settling tanks were built. This plant was first operated in November.

Lessees on the Connor land at Prosperity were large producers of lead and had the second largest output of sphalerite. Many new leases were drilled, numerous shafts sunk, and several new mills built. The shipments of concentrates from mines on the Connor land were three times as large in 1915 as in 1914, and some of the new mines opened proved to be very profitable. "Sheet ground" was mined by the Cumberland Mining & Milling Co., McDonald Mining Co., Cygni Mining Co., and Jasper County Mining Co. Nearly all the lead and most of the sphalerite shipped was derived from "sheet ground."

The concentrates from the Googie, Dixie, Seneca, Tom C., and Ten O'Clock mines were mainly sphalerite derived from "soft ground." Among the new mines opened was the Googie, at which a 150-ton mill was built. After the owners had operated this mill for a few weeks both lease and equipment were sold to the National Lead & Zinc Co. Another lease which was sold after a shaft had been sunk and considerable rich ore placed on the dump was that of the Cinomo Mining Co. The Tom C. and the Seneca mines developed by Thomas Coyne proved to be large producers and the expense of opening and equipping them was repaid within a few months. The Dixie mine was leased by O. K. Symmes, who practically rebuilt the mill, which now has a capacity of 500 tons in 24 hours. The Katy C. mill was used as a custom plant by Talbot & Miller.

The lands of the American Zinc, Lead & Smelting Co., as usual, were the largest producers of galena in the district and the third largest producers of sphalerite. The Davey mines Nos. 3 and 4 produced nearly all the concentrates shipped. The new 300-ton mill of the Queen Esther Mining Co., on American land, was not finished in 1915.

The S. Y. Ramage lease was, as usual, the principal producer on the Center Creek Mining Co.'s land. Other productive mines or mills

were those of the Incline Mining Co., Carolet Mining Co., Twin City Mining Co., Aikins, Curtis & Cosden, J. R. Wisby & Co., Central Milling & Concentrating Co., and the Mercedes Mining Co. Six milling plants having an aggregate capacity of 1,200 tons (10 hours) are owned by the lessees.

The producing mines on the Ware, Bowman & Scott land in the north Webb City section were the C. & S. No. 2 (old Princess), C. & S. No. 4 (old Genessee), and the Wingfield. All were large producers from "sheet ground." The new equipment at the Wingfield consists of 2 electric motors, 1 Dorr classifier, 1 40-foot Dorr thickener, 4 James sand tables, and 4 James slime tables. The Bertha A. Mining Co. is on the adjoining land of the Newell Morse Royalty Co. This mine and mill is one of the most completely equipped and also one of the largest producers in the Joplin region. The concentrating plant is run by electric power and has a capacity of 1,000 tons in 24 hours. In the mill building there are 6 Arbuthnot and 4 Ford tables. The additional equipment at the separate sludge plant erected in 1915 was as follows: Two 34-foot Dorr tanks and thickeners, 1 Dorr classifier, 5 James sand tables, 7 James slime tables, and one 40-horsepower motor. A gasoline engine was also installed to pump slimes from the pond to the thickeners when the large concentrating plant is not operating.

The output of the lessees of the Kelly Land Co. more than doubled, though no new concentrating plants were erected. The principal lessees were the C. & S. No. 1 mine (old Imperial), the Cisco Mining Co., and the D. C. & E. Mining Co. on the Osceola lease. The largest producer on the Big Stick Mining Co.'s land was the Star Mining Co. The mill which has a capacity of 400 tons was overhauled and a sludge plant containing 11 tables was built. The John L. Mine was leased by the C. & S. Mining Co. and after being put in repair was known as the C. & S. No. 5. The tailings at the Goode mine were re-run by the C. C. & H. Mining Co.

On the Carter estate at Prosperity the mine formerly operated by the Florine Mining Co. was transferred to the Milan Mining Co., and the Century Zinc Co. purchased the Laminite mine and mill. The most important development in the district, which did not result in any extraordinary addition to the production in 1915, although it will add very appreciably to that of 1916, was made by the Zinc Corporation of Missouri. This corporation, headed by T. J. Franks, secured leases on the Dougherty Davy, McGregor, Ealor, South Carterville, Edgar, Luscombe, Burgner, and Missouri Zinc Fields lands, aggregating in all 770 acres. These tracts were known to contain large bodies of ore, in both "sheet ground" and "soft ground," which had not been mined for 8 or 9 years because of the heavy expense necessary to lower the water level. The average prices for ore had not justified the installation and maintenance of a big pumping plant on any one tract. After leases had been secured on the whole body of land that could be drained by one central plant, large acid-proof pumps began work in April and the entire tract was drained in July. Prior to and after the successful draining of the land many leases were given on the property, prospecting by means of drilling was very active, old shafts and drifts were opened, and several concentrating plants were erected or rebuilt. The mills which were oper-

ated and which produced concentrates in 1915 were those of the Missouri Zinc Fields Co., Kirkwood Mining Co., and Hornbrook Mining Co., and the Kusterer custom mill. Of these mills the Kirkwood and the Hornbrook treated ore from "sheet ground". New mills were under construction by the Wallower Mining Co. on the Homestead tract, Queen Esther Mining Co. on the Richland tract, J. F. Dexter on the Cornfield tract, Ben Franklin Mining Co., Mattes Bros. (Carey lease) on Missouri Zinc Fields tract, and Mattes Bros. on the McGregor tract.

Some of the older producing mines, many of which were operated double shift and had a much increased output, were the Ruby D. Mining Co., on the Aylor land; the Smith mine, on the Van Hoose land, now owned by the Gopher Mining Co.; the Beulah S. mine, on the Bradford-Kansas City Mining Co.'s land; the Twin City and Orange mines, on the Carterville Mining & Smelting Co.'s land; the Munson Mining Co., on Continental land; the Gobbler mine, on E. J. Chinn land; the Corona and Cygni mines, on the General Lead & Zinc Co.'s land, and the W. E. Saum (old Troop) mine.

The production of the Schoolhouse Mining Co. on Chapman Bros. land, was more than doubled by additional equipment at the mill, which is now capable of treating 400 tons of "dirt" in 10 hours. A new 100-ton mill was built on the C. E. Elliott land, which was operated the latter part of the year. The old Providence mine, operated by Steers & Rice (now Big Run Zinc Co.), had a good output from "sheet ground." Ore has been located in "soft ground" at this property, which should result in an increased production.

The H. M. Baker 120-acre tract, in the north Webb City section, was not mined in 1915. The land was purchased by the Fremont Mining & Milling Co., and it is stated that pumps will be started to drain the entire tract.

CENTRAL AND SOUTHEASTERN MISSOURI.

The ore deposits of central and southeastern Missouri reach in a more or less connected belt from the region of Benton, Pettis, Morgan, Moniteau, Cole, and Miller counties on the northwest to the northern and eastern flanks of the St. Francis Mountains on the southeast. It is also true that there are scattered areas where more or less mining has been done all the way between the northwest end of this belt and the Joplin region, so that strictly speaking the lead and zinc deposits of Missouri practically form a zone around the northern half of the Ozark dome.

The deposits in the counties named above, corresponding to the central Missouri region, are of the general type of those in the Joplin region, in that the ores consist of galena and sphalerite, or the oxidized derivatives of those minerals, and occur in association with solution breccias and sink-hole shale patches, the ore being found in the Cambrian and Ordovician dolomites and included cherts and occasionally in the Pennsylvanian shale. The occurrence of ore in crevices or thin vertical sheets is very common, but practically all the production of ore has been obtained from sink-hole breccias or "circles," a form of deposit noted as also important in the southwestern Missouri area.

The southeastern part of the belt, in the vicinity of the St. Francis Mountains, forms the disseminated lead region of southeastern Missouri. The earlier workings were shallow, and even yet considerable shallow lead is raised, generally in connection with the mining of barytes, or "tiff," as it is locally known. The mines in the disseminated lead region range from 100 feet to about 550 feet in depth, depending on the depth from the surface to the basal portion of the Bonneterre limestone.

The ore deposits now worked are almost wholly in the lower part of the Bonneterre limestone, where they occur in disseminated form over large areas, relatively richer in the vicinity of the intersecting crevices and joints. The crevices show little if any displacement, and there are no breccias of consequence. The copper, nickel, and cobalt in Madison County occur with galena and marcasite in blanket formation in the carbonaceous beds of parting at the contact of the Bonneterre limestone with the Lamotte sandstone below, and in the vicinity of the intersection of this contact with the sloping surface of the pre-Cambrian rocks. Both the Bonneterre and the Lamotte formations are of Cambrian age.

Prospecting is done by means of the diamond drill, and extensive campaigns of drilling have been prosecuted in the vicinity of all the important producing tracts.

The diamond drill is also used in mining as an aid in following the ore. Cores are taken from the heading in various directions, straight ahead, at angles upward, downward, to the side, and from these cores the direction to drive the heading is determined.

The ore in the southeastern Missouri region is almost wholly lead, although a considerable zinc deposit occurs at Valle mines, some 6 miles north of the Bonneterre district. A certain percentage of zinc is also found in the disseminated lead ore, the ore from one shaft being reported to run occasionally as high as 2 per cent of zinc for a week at a time. The zinc occurs more plentifully in the Leadwood-Flat River district and may lie near the contact of the Bonneterre limestone with the Lamotte sandstone or some distance above it. In the lead concentrates zinc ranges from 1 to 5 per cent or more. In the maximum proportions mentioned the zinc makes trouble in lead smelting, and for this reason some of the concentrating plants remove the zinc as a table middling. A small quantity of low-grade sphalerite concentrates was shipped in 1915 by the Federal Lead Co.

Copper, nickel, and cobalt also occur in the ore, in great quantity in the vicinity of Fredericktown, and in small quantity, irregularly, in nearly all the deep mines. It is only near Fredericktown that the copper, nickel, and cobalt content of the ore has been the object of mining, yet a concentrate of these metals has been recovered as a table middling at several plants in other parts of the district, and 3,115 tons of copper concentrates were shipped in 1915. These copper concentrates, from which 382,700 pounds of copper were recovered, were from the Federal, Desloge, Mine La Motte, St. Louis, and St. Joseph mines. In the disseminated ore district the production since 1869 increased rapidly and is estimated by Buckley to have amounted to 1,202,607 tons of lead concentrates, valued at $59,869,354 for the period between 1869 and 1906, inclusive. The mine production of southeastern and central Missouri has been reported to the United States Geological Survey since 1907.

Mine production of lead and zinc concentrates of southeastern and central Missouri, 1907–1915.

Year.	Lead concentrates—galena.		Zinc concentrates.			
			Sphalerite.		Carbonate and silicate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1907	156,663	$7,910,398	100	$3,500	1,095	$15,330
1908	183,095	6,906,116	42	1,050	1,369	20,436
1909	210,620	8,823,297	41	938	1,284	17,334
1910	210,890	9,360,309			929	19,000
1911	219,145	10,293,400	113	3,990	510	11,576
1912	218,803	9,849,854	40	1,292	1,051	21,020
1913	219,511	9,580,893	33	574	639	13,491
1914	249,165	9,710,125	40	700	497	11,282
1915	278,104	12,773,579	43	1,064	1,061	39,460
	1,945,996	85,207,971	452	13,108	8,435	168,929

A comparison of the estimates for the period of years to 1906 given by Winslow and by Buckley for Washington and St. Francois counties (which have supplied a very large per cent of the galena ores from southeastern and central Missouri) with the figures in the preceding table apparently indicates a production of galena concentrates during the last nine years greater than the entire output of southeastern and central Missouri prior to 1907.

The lead ore of southeastern Missouri carries a small proportion of silver, the average being a very little over 1 troy ounce to the ton of lead concentrates. The resulting pig lead likewise carries silver, together with a little copper, nickel, cobalt, and traces of antimony and arsenic, and is sometimes commercially known as "Missouri chemical" lead in contradistinction to "Missouri soft" lead from the Joplin region. An average of about 15 per cent of the total lead concentrates from southeastern Missouri is desilverized. The silver so recovered does not pay for the refining charges, but the desilverized lead commands a slightly higher price, making up the difference. As the silver content of the concentrates is so small, it is disregarded in their sale, and therefore the smelter reports are relied upon for the silver production. As already explained, the quantity of silver produced during any year bears no direct ratio to the quantity of silver-bearing lead concentrates smelted during that year, for the reason that the silver bullion is stored and refined in batches at convenient times.

The silver output of Missouri in 1914 was derived almost entirely from lead concentrates, the only other source of production being a small quantity recovered from copper matte shipped from the smelter of the Missouri Copper Mountain Mining Co.

The silver production of southeastern Missouri was 57,756 fine ounces in 1915, as compared with 61,168 fine ounces in 1914, 35,620 fine ounces in 1913, 34,438 fine ounces in 1912, 49,867 fine ounces in 1911, 33,096 fine ounces in 1910, 14,188 fine ounces in 1909, and 49,131 fine ounces in 1908. The silver production of 1915 was recovered from 64,377 tons of lead concentrates and from copper ore that averaged 0.09 ounce per ton.

The crude lead ore mined in 1915 amounted to 5,067,400 short tons, against 4,718,300 short tons in 1914, 4,250,800 short tons in 1913, and 4,064,366 tons in 1912. The crude ore in 1915 yielded 5.47 per cent of lead concentrates, which averaged 66.5 per cent of lead. The average value per ton of the lead concentrates in 1915 was $45.89, as compared with $38.96 in 1914, and the concentrates were slightly lower in lead content than in 1914. The output of galena concentrates was 278,104 tons, valued at $12,773,579, in 1915, against 249,165 tons, valued at $9,710,125, in 1914. As several of the large producers not only mine but also smelt their lead concentrates, the values given for concentrates are arbitrary to a certain extent. The galena concentrates produced in the southwestern Missouri region containing a higher lead content are mainly sold on bids from various purchasers, and the prices for those lead concentrates are not comparable with prices given for concentrates of the disseminated lead district.

The production of sphalerite from central and southeastern Missouri in 1915 amounted to only 43 tons, valued at $1,064, which was slightly more than in 1914. The production of zinc carbonate from southeastern Missouri in 1915 amounted to 1,061 tons, against 497 tons in 1914.

The output of lead recovered in mining shallow diggings in Washington and Jefferson counties was slightly less than in 1914, and the yield of lead and zinc from central Missouri was small.

The more general use of the flotation process for the treatment of slimes in the disseminated lead region resulted in an increased recovery of concentrates from the ore treated. It is not probable that the ore mined and treated was richer in 1915 than in 1914, but the percentage of recovery of concentrates from ore was 0.20 per cent more than it was in 1914. Stated differently, the quantity of ore mined and milled in 1915 increased less than 8 per cent, but the recovery of galena concentrates increased more than 11 per cent. A brief review of the flotation practice in Missouri is given by L. A. Delano.[1]

The production of galena concentrates from the disseminated lead district was the largest ever recorded, exceeding that of 1914 by about 28,896 tons. Labor conditions were generally satisfactory and there were no strikes of any magnitude.

REVIEW BY COUNTIES.

Cole County.—No ore was mined at the Black Jack mine in 1915, but mining will be resumed in 1916. Galena ore mined by means of shallow shafts was shipped by Reuben Cole, of Russellville.

Franklin County.—The Missouri Copper Mountain Mining Co. mined, by means of open cuts, copper ore which was smelted in a small cupola furnace. The matte shipped from this furnace, which was operated in July and August, assayed 43.18 in copper.

Moniteau County.—Some lead and sphalerite concentrates were recovered by the Monarch Coal & Mineral Co. at Excelsior. The zinc concentrates, which were high grade, were sold. The sphalerite and galena occurs with cannel coal and black slate.

Washington County.—Several companies owning large tracts of land in Washington County, such as the Washington Land & Mining

[1] Min. and Sci. Press, Apr. 29, 1916, p. 633.

Co., the Southeast Missouri Lead Co., the Pioneer Mining, Mercantile & Land Co. (successors to the Renault Lead Co.), work their property on a royalty basis. The ore, which occurs at shallow depths and in association with barytes, is mined in a small way and at odd times by the barytes miners. This ore is all hand picked and cleaned, there being no concentrating plants. There are numerous other shallow lead and barytes diggings scattered over Washington County which are worked by small operators and farmers, who sell their product to the country merchants and to ore buyers. Much of this ore was purchased by James Long, of Potosi, Buren Duckworth, of St. Claire, and P. G. Higginbotham, of Fertile.

Both galena and zinc silicate concentrates were shipped in 1915 by lessees of the Potosi Lead, Barytes & Mercantile Co., and by Hugh McGregor, of Potosi.

Jefferson County.—The Valle Mining Co., with offices at Valle Mines, in Jefferson County, operates partly on a royalty basis, a large tract of land, about half of which lies in St. Francois County. The ores are galena and zinc carbonate and are found at depths ranging down to 225 feet, depending on topography. The yield of galena concentrates was less than in 1914, while the output of zinc carbonate increased. Work in the new No. 5 shaft continued throughout the year, with the result that good carbonate ore was developed which should yield a larger output. The shaft is being equipped with a hoist and oil-driven compressor to operate hammer drills. The installation is being made by the Ingersoll-Rand Co. The shaft has been connected by drifts to the old workings on the 160-foot level. Four of the old shafts have been recribbed and are operated by lessees.

The second largest output of zinc carbonate from southeastern Missouri was that of the Merseal Allee Timber Co., of De Soto. The ore, which was all hand cobbed, was taken from shallow workings. Surface mining was done on the Pinnell land at Fletcher by Johnson Bros., and small shipments of galena and zinc silicate were made.

St. Francois County.—The St. Joseph Lead Co. (a description of whose mines, surface, and smelter equipment is given in the Central States report for 1912) reported the recovery of the largest quantity of galena concentrates from the southeastern Missouri region. Flotation is used in connection with both concentrating plants, which have a combined capacity of 3,600 tons a day. The ore treated in 1915 was hoisted from shafts Nos. 1, 2, and 12. Some drilling was done on the Puegnet 400-acre tract in West Bonne Terre.

The Doe Run Lead Co. operated four to six shafts during the year in the Flat River district. The 4,000-ton mill of this company is one of the best equipped in the district. The building is of steel construction throughout. The mill machinery is operated by alternating current 440-volt motors, which receive their current from the central gas-electric power station at River mines. All shaft equipment, such as hoists, compressors, underground pumps, are motor driven. Four 800-horsepower Snow twin tandem gas engines, direct connected, each with a 600-kilowatt generator, furnish power to all shafts and mill machinery. The gas-producer plant has four 800-horsepower Loomis-Pettibone producers and one 1,000-horsepower Westinghouse producer.

The underground haulage at shafts Nos. 1 and 4 is done by air locomotives. At all other shafts mules are used. Copper concentrates shipped in 1915 amounted to 657 tons.

The Desloge Consolidated Lead Co. in 1915 operated 3 shafts, 2 of which are about 300 feet and the other is 600 feet in depth. Two of the shafts are near the town of Desloge, but No. 4 shaft is near Leadwood. The concentrating plant is equipped with 2 Hancock jigs, 30 Wilfley tables, 10 Frue vanners, and appropriate rolls, Chile mills, and Dorr thickeners and flotation tanks. The capacity of the concentrating plant is 1,700 tons per day of 24 hours. Electric pumps were substituted for the steam pumps used underground. The smelter near the concentrating plant is equipped with 4 Flintshire-Tarnowitz reverberatory furnaces, only 2 of which have been operated in recent years, the "gray" slag being sold to other smelters.

The production of galena concentrates in 1915 was slightly larger than in 1914.

The St. Louis Smelting & Refining Co. has its mines in the vicinity of the village of St. Francois, about 1 mile north of Flat River. Three shafts, from 208 to 565 feet deep, were in operation in 1915. The bottom of the ore was reached in shaft No. 6 at 540 feet and the Lamotte sandstone at 560 feet. The concentrating plant is modern, having a capacity of 2,400 tons per day of 24 hours, and is equipped with Hancock jigs, Overstrom classifiers and tables, Frue vanners, and slime and settling tanks. A central steam power plant drives air compressors and electric generators. The mill, hoists, and pumps are operated by electricity, as well as the underground haulage, and the trams for handling the ore from the shafts to the mill. This company also operates a lead smelter and refinery at Collinsville, and the lead concentrates produced by the mines, and also those derived from crude ore purchased from the Baker Lead Co., formerly known as the St. Francois Lead Co., were smelted at that plant.

The production of lead concentrates in 1915 was considerably larger than in 1914.

The Baker Lead Co. purchased the old John Day tract from the St. Francois Lead Co. and also acquired the Jones 40 acres at Elvins, on which a new shaft to be sunk 650 feet was begun.

The Federal Lead Co. operated 4 shafts during 1915, mining and milling 1,355,000 tons of crude ore. The capacity of the mill is 4,600 tons per day; the mill is equipped with 12 Hancock jigs, 72 tables, and 18 vanners, arranged in 3 units of 2 sections each. There are also regrinding rolls, elevators, and Esperanza-Federal drag classifiers, and a supplementary slime treatment. During 1915, in addition to the regular lead concentrate shipments, 900 tons of copper concentrates, averaging 2.9 per cent copper, and 30 tons of zinc concentrates, averaging 26.8 per cent zinc, were shipped. These concentrates were recovered as a by-product by means of a roasting-magnetic separating plant.

During the year sinking and equipping a new shaft to be known as No. 12 was commenced. This shaft will be 450 feet deep, and the hoisting will be by means of an electric hoist operating two 4½-ton skips. The ore will be brought to Mill No. 3 for milling. The mines and mill are near Flat River in St. Francois County.

The Phœnix Lead Co. and the Fleming properties in Madison County, near Fredericktown, were operated under lease by the Fed-

eral Lead Co. beginning with May, 1915. Approximately 400 tons of crude ore per day were mined and milled therefrom.

Madison County.—Four shafts and several prospects were operated during 1915 by the Mine La Motte Co. on a tract which was first mined in 1720. The shallow deposits which were first worked were followed down to a depth of 100 to 125 feet, and from this level the ore has been coming that for 50 years has supplied the mill and smelter. The mill, which is practically new, has a capacity of 800 tons per day of 24 hours, and is equipped with Hancock and Harz jigs and tables. The attempt was made some years ago to smelt the copper and nickel-cobalt sulphides, which in certain parts of the mines occur plentifully with the lead and are separated in concentration. Of late years these ores have been avoided and attention in mining has been limited to the lead ores.

OKLAHOMA.

By J. P. Dunlop.

PRODUCTION.

Production of lead and zinc in Oklahoma in 1915.

District.	Ores.					
	Lead concentrates (galena).		Zinc concentrates.			
			Sphalerite.		Carbonate and silicate.	
	Quantity (Short tons).	Value.	Quantity (Short tons).	Value.	Quantity (Short tons).	Value.
Ottawa County:						
Miami	8,976	$490,117	26,802	$1,781,821		
Peoria	[a] 211	11,845			172	$5,666
Quapaw	82	4,407	1,478	119,669		
Murray County: Davis			132	9,912		
State total, 1915	9,269	506,369	28,412	1,911,402	172	5,666
1914	9,402	443,543	28,365	926,738	8	140

District.	Metal content.[b]			
	Lead.		Zinc.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Ottawa County:				
Miami	7,085	$665,990	13,426	$3,329,648
Peoria	158	14,852	60	14,880
Quapaw	63	5,922	765	189,720
Murray County: Davis			63	15,624
State total, 1915	7,306	686,764	14,314	3,549,872
1914	7,556	589,368	13,992	1,427,184

[a] Includes a small quantity of lead carbonate.

[b] In calculating the metal content of the ores for assays allowance has been made for smelting losses in the case of zinc but not in the case of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer, whereas the value of the lead is calculated from the average daily quotations at New York. The zinc price for 1915 is the avearge sales price reported by smelters.

The following table gives the crude lead and zinc ore output for the whole State of Oklahoma, but it was thought advisable to calculate the tenor of crude ore and concentrates as well as assay content and value of concentrates separately for the Miami and Quapaw districts, inasmuch as the character of the ground operated in these districts differs so radically that general calculations for the State would be valueless:

Tenor of lead and zinc ore and concentrates produced in Oklahoma, 1914 and 1915.

	1914	1915		1914	1915
Total crude ore milled in Oklahoma.....short tons..	763,920	891,800	Quapaw district:		
Miami district:			Total concentrates in crude ore—		
Total concentrates in crude ore—			Lead.....per cent..	.....	0.12
Lead.....per cent..	1.24	1.10	Zinc.....do....	3.82	2.14
Zinc.....do....	3.84	3.28	Metal content of crude ore—		
Metal content of crude ore:			Lead.....do....	.....	.09
Lead.....per cent..	1.00	.86	Zinc.....do....	2.14	1.23
Zinc.....do....	2.03	1.82	Average lead content of galena concentrates, per cent.....	79.00	76.8
Average lead content of galena concentrates, per cent.....	80.00	78.9	Average zinc content of sphalerite concentrates, per cent.....	56.2	57.5
Average zinc content of sphalerite concentrates, per cent.....	54.8	55.7	Average value per ton—		
Average value per ton—			Lead concentrates....	$50.00	$53.74
Galena concentrates..	$47.19	$54.60	Sphalerite concentrates.....	$34.87	$80.97
Sphalerite concentrates.....	$32.66	$66.48			

The Oklahoma lead and zinc chapter in Mineral Resources for 1914 contains a brief history of mining in the various districts and also the estimated total production of each district, by years.

Production of lead and zinc concentrates in Oklahoma, 1891–1915.

District.	Lead concentrates (mainly galena).		Zinc concentrates.			
			Sphalerite.		Zinc silicate and carbonate.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Peoria [a]	1,894	$87,170	56	$616	2,243	$51,907
Quapaw	3,560	217,700	28,669	1,161,740	164	2,692
Miami	42,341	2,192,589	124,727	4,877,637	.....	.....
Davis	.....	.....	407	20,754	558	9,660
	47,795	2,495,459	153,859	6,060,747	2,965	64,259

[a] Estimates for district incomplete, but are the best available.

The production of lead and zinc ore in Oklahoma in 1915 was approximately the same as in 1914, though the value of recoverable metals was more than doubled. In none of the Central States was development more active than in the Oklahoma districts and the extended area of proved territory insures a large output for years under normal conditions. Many new mills were built or were under construction in the territory northeast of the original camp. Most of these, however, did not contribute to the 1915 output and the few that did so

were being opened and developed, so their output was not so large as it will be.

The town of Commerce grew from a small village to a thriving, busy place of several thousand inhabitants. New camps, called Cardin and Picher, northeast of Miami, followed the trend of development, and substantial roads were being made. The Oklahoma, Kansas & Missouri Inter-Urban Railway is extending its line from Commerce to Cardin and Picher, and spurs will be run to the mines so that ore shipments and construction work can proceed more rapidly.

Many old properties in the Quapaw and Peoria districts were reopened, mills were rebuilt, and new territory was drilled. The production from these districts was more than ten times as large in 1915 as in 1914.

Mining in the Davis district, Murray County, in southern Oklahoma, was revived after an idleness extending over two years, and some sphalerite was shipped.

The value of the recoverable lead and zinc produced at mines in Oklahoma in the year 1915 was $4,236,636, compared with $2,019,973 in 1914. The metal content of lead concentrates decreased from 7,556 tons, valued at $589,368 in 1914 to 7,306 tons valued at $686,764 in 1915, and the recoverable zinc increased from 13,992 tons, valued $1,427,184, to 14,314 tons, valued at $3,549,872.

In 1915 the lead concentrates produced in the Oklahoma districts were of slightly lower grade than those shipped in 1914. The average metal content of the sphalerite concentrates from Miami ore increased from 51.8 per cent in 1912 to 53.6 per cent in 1913, to 54.8 per cent in 1914, and to 55.7 per cent in 1915, and was only 1.8 per cent less than the average metal content of the sphalerite from the Quapaw district in 1915.

The lead concentrates from Oklahoma sold in 1915 were 132 tons less in quantity and $62,826 greater in value than in 1914. Miami district produced more lead than any district in the Joplin region, with the exception of Webb City-Carterville, and its yield was equal to about one-fifth of the production of the Joplin region. The Oklahoma shipments of sphalerite in 1915 amounted to 28,412 tons, valued at $1,911,402. This was an increase of 47 tons in quantity and of $984,664 in value.

The shipments of zinc carbonate and silicate increased from 8 tons in 1914 to 172 tons, valued at $5,666, in 1915. The Miami district yielded more than 94 per cent of the sphalerite concentrates and 93 per cent of the galena concentrates sold in Oklahoma in 1915.

The lead and zinc deposits of northeastern Oklahoma, so far as known, are confined to the limits of Ottawa County and form the southwestern extension of the Joplin region. There are three camps, Peoria, Quapaw, and Miami, in this county, in which extensive mining has been done, and a fourth, the Sycamore Creek district, along the Seneca fault block from 2 to 3 miles southwest of Seneca, Mo., in which considerable prospecting has been done and some ore mined.

The lead and zinc deposits in southern Oklahoma are near Ravia, at the southeast end of the Arbuckle Mountains and near Davis, Murray County, at the northwest end of the same range.

REVIEW BY DISTRICTS.

Peoria district.—Peoria is the oldest mining camp in the State, and galena and blende principally were mined in the beginning, but in recent years the small output has been mostly of carbonate and silicate ores. The estimated total production of zinc silicate concentrates for the period 1907 to 1915 is 1,792 tons.

Absence of railway transportation has retarded the development of the camp, and mining operations have always been intermittent. In 1907 a small mill was erected by the Chicago Syndicate Mining Co., and ore bodies were mined at the 140 and 160 foot levels on its property. The mill has never been run steadily, and very little prospecting for ore at deep levels has been done. This mill, which is on the Geboe land, has been leased by the Nellie Bly Mining Co., and the mine is being drained.

There were quite a number of miners working the shallow deposits of galena and zinc silicate on the Geboe, Ray, Helling, Scott, Charter, Mountjoy, and other lands in 1915. The aggregate shipments were 211 tons of galena and 172 tons of zinc silicate, which were hauled to Galena, Kans., and Joplin, Mo.

Quapaw district.—The Quapaw district [1] mines extend from 1 to 4 miles east of Quapaw and from 5 to 7 miles south of Baxter Springs, Kans. The first shaft in the district was sunk in 1904 on the Abrams land.

Some shallow silicate and galena has been mined, but the chief production is blende and galena ores from sheet ground at a depth varying from 80 to 150 feet. This sheet is known as a blanket breccia, because the ore occurs in crevices and in the cement of the chert breccia and not between the chert sheets, as in the typical sheet ground of the Webb City (Mo.) district. The ore is associated with pink spar and jasperoid, but aside from the pink spar otherwise is similar to the "sheet ground" ores.

As in other districts of the Joplin region there was a great revival in mining in this district. Nearly all the old milling plants were repaired and flooded mine workings were pumped out. Several new mills were erected, some of which were in operation for a short period only in 1915. The production increased from 1 ton of galena concentrates, 146 tons of sphalerite concentrates, and 2 tons of zinc silicate concentrates in 1914 to 82 tons of galena and 1,478 tons of sphalerite in 1915. The total value of the concentrates sold increased $118,895. The estimated total production of the district to the end of 1915 is 3,560 tons of galena, 28,669 tons of sphalerite, and 164 tons of zinc silicate.

One-third of the production of galena and one-half of that of sphalerite was shipped by the Ruby W. Mining Co. from the old Katy and Mission mines. These mines adjoin and each is equipped with a large concentrating plant.

The old Myrtle mine on the Buck land was acquired by the Anchor Zinc Co., which built a 200-ton concentrating plant. Ore was hoisted by one shaft from the 87-foot level. The mill was not completed until about November 1, but the production during the rest of the year was satisfactory. The Sambo Mining Co. drilled a lease on the Buck land,

[1] Siebenthal, C. E., Mineral resources of northeastern Oklahoma: U. S. Geol. Survey Bull. 340, pp. 187-228, 1907.

sunk a shaft, and began building a mill, which was not finished in 1915. The Lincolnville mine on the Paul Ewart land was leased to the Maybelle Mining Co. The mill was practically rebuilt, the ground unwatered, and a steady output of zinc concentrates made the latter part of the year.

The active lessees on the A. W. Abrams land were Homer Seals, who operated the White Eagle mill, and the Mohawk Mining Co., which has a small mill that treated ore from the Sunnyside and Last Chance mines.

The only production of the Mulberry Mining Co. on the Newhouse land was a small quantity of sphalerite and galena taken from a 35-foot shaft. The Hannibal-St. Joe Mining Co. had only a small production, as the mill was not reconstructed and the surface equipment repaired until late in 1915. The Red Eagle ore shipments in 1915 were composed entirely of galena. The mill at this mine has a capacity of 50 tons. Considerable drilling was done on the Horse Shoe, Dardenne, Ewart, and Timothy lands, and some old mills were repaired but not operated.

Miami district.—A history of the mining in this district, including the output by years for the period 1908 to 1914, and the location of the mines and mills, was given in this report for the year 1914, copies of which can be obtained on request. The data given in the following reviews relate chiefly to production, new territory prospected, new mines opened, and new mills built in 1915.

The mines of the Miami district in 1915 shipped 8,976 short tons of galena concentrates, valued at $490,117, and 26,802 short tons of sphalerite concentrates, valued at $1,781,821. This shows a decrease of 425 tons of galena concentrates and of 1,417 tons of sphalerite concentrates when compared with the output of 1914. As the average selling price of both lead and zinc concentrates was higher than in 1914, the total value of the concentrates shipped from Miami in 1915 was $916,798 greater than in 1914. Of this increase $860,174 was for sphalerite concentrates.

It must not be assumed that because there was a slightly smaller production from the Miami district in 1915 than in 1914, notwithstanding the prevailing high prices paid for sphalerite concentrates, that the mining industry was not as active as conditions warranted. In no other district in the Joplin region or in the Central States was there more drilling accomplished, more new territory opened, or more money paid for new leases and for development work of every description. The town of Commerce more than doubled in population and in property values. New towns called Cardin and Picher came into existence as the tide of mining development spread to the northeast. Bad roads hampered mill construction and the shipment of supplies and concentrates. This condition was remedied in part by building a substantial rock road from Commerce to the Kansas line. The extension of the Oklahoma, Kansas & Missouri Interurban Railway from Commerce to Picher, with spurs to the various mines, will provide shipping facilities equal to those in other large districts of the Joplin region. There were practically no idle mines and mills which could be purchased and quickly made producers. New mines had to be developed and all surface equipment erected. The ore bodies lie at depths lower than in most districts of the region, and frequently pumps of large capacity were needed to free the mines from water.

The quantity of crude ore mined and milled increased from approximately 760,000 tons in 1914 to 817,000 tons in 1915. The percentage of concentrates recovered from crude ore milled was larger than in any other district in the Joplin region, though with increased operations and high prices of ore the "dirt" treated showed a natural decline in percentage of concentrates recovered—from 5.08 per cent in 1914 to 4.38 per cent in 1915. The average metal content of all of the blende concentrates sold increased from 51.8 per cent in 1912 to 53.6 per cent in 1913, to 54.8 per cent in 1914, and to 55.7 per cent in 1915. The separate assays reported showed the zinc content to range from 46.5 to 62.5 per cent, but most of the blende assayed between 52 and 58 per cent. Assays of 740 lots of zinc concentrates by Thor Relling, of Miami, in 1915, showed an average content of 55.9 per cent zinc and 3.05 per cent iron, and the average lead content of 171 lots of galena concentrates assayed was 78.95 per cent. These assays reported by Mr. Relling very closely approximate the average lead content of galena concentrates and the zinc content of sphalerite concentrates given in the table for the Miami district. The average selling price of galena concentrates increased from $47.19 in 1914 to $54.60 in 1915, and that of blende concentrates increased from $32.66 in 1914 to $66.48 in 1915.

The recovery of galena concentrates from all the mines averaged about 1 ton to 3 tons of sphalerite, which is much higher than in any other district in the Joplin region. The proportion of galena concentrates recovered from the "dirt" mined showed wide variations, ranging in different mines from 1 ton of galena to 30 tons of sphalerite to 1.6 tons of galena to 1 ton of sphalerite. The mines lying north of the original Miami camp reported 5,897 tons of galena and 9,972 tons of sphalerite, while those in the original Miami camp reported the production of only 2,886 tons of galena to 14,435 tons of sphalerite. The lowest proportion of galena to sphalerite was reported by the few mines at the extreme southwest corner of the district, which produced 193 tons of galena and 2,395 tons of sphalerite.

Prior to 1912 most of the ore was derived from the upper runs of ore, which varied from 90 to 130 feet in depth. By the end of the year 1911 much of the ore between these depths had been exhausted in many of the mines and, though several mines operated on the upper run of ore very successfully, an increased proportion of the ore treated in 1913, 1914, and 1915 was taken from a run of ore below the 200-foot level. One mine reported ore mined from 160 and 180 feet, which was not as good as that obtained from either the upper or lower runs. The draining of the ground by the large centrifugal pump placed in a shaft on the Miami Zinc & Lead Co.'s lease, on the Emma Gordon land, gradually lowered the water level to 365 feet by the end of 1915, and ore was hoisted from levels as low as 250 feet in the southern mines of the camp. The ore hoisted from the mines in the northeastern and northwestern parts of the camp came from depths of 200 feet to 290 feet, except that at the Cornfield mine, which came from the 145-foot level. The blende concentrates from the lower run in the southern area are of much better grade than those obtained from the upper ore run, which averaged about 50 per cent zinc.

Drilling operations were steadily carried on, not only ahead of the drifts in the mines opened and to explore the ore in lower levels at

the old mines, but also in an extensive area reaching east of Tar Creek to the developed mines near Lincolnville, north into Kansas, west of Commerce, and southwest across Neosho River. The percentage of prospect holes showing ore was larger than of those which were reported blank. The drilling was done by many land owners and lessees, including the Commerce Mining & Royalty Co., Church & Mabon, Picher Lead Co., Barnes & McConnell, T. T. Lennan, Temple Chapman, Denver Miami Mining Co., R. D. Talmadge, O. W. Sparks, W. O. Cardin, Underwriters Land Co., Walker Mining & Development Co., J. H. Jones, Day Cooter & Co., and Standifer Bros. Much of the drilling was done in the territory east of Tar Creek and north toward the Kansas State line, but some was done on land northwest of Miami and west and northwest of Commerce.

The most southwestern producing area in the Miami district is that lying about 1½ miles northwest of the city of Miami and locally termed the Horse Shoe Lake camp, first developed by McConnell & Barnes. Northeast of the group of mines at Horse Shoe Lake and southwest of Commerce is another less developed area on McCuddy Crang & Co.'s land. The combined production of these southwesterly mines in 1915 was 193 tons of galena, valued at $10,130, and 2,395 tons of sphalerite, valued at $196,763.

The McConnell-Barnes Mining Co. was the largest producer. In 1915 the mill shaft at this mine was sunk from 215 feet to 228 feet and the shaft 300 feet northwest of the mill was sunk from 98 feet to 228 feet. The mill shaft was the only one used in 1915. The Denver Miami mine northeast of the McConnell mine was bought by O. W. Sparks, the owner of the Sparks mine adjoining it. Both mines are located on the McConnell & Barnes lease of the McBee land and are now operated as the Denver & Miami Mining Co. There was a 225-foot shaft at each mine and a new 150-ton mill was built in 1915 at the Denver Miami mine. Prior to the merger of the properties all the concentrates recovered at the Sparks mine were obtained by means of hand jigs. The Herbert Mining Co. on the McCuddy Crang & Co. land recovered both lead and zinc concentrates by means of 4 hand jigs from ore mined at a depth of 90 feet. Some drilling was also done on this land by J. H. Jones.

The old mines at Commerce from the Mispah mine, the farthest south, and those on the northwesterly ore run extending to the Vantage mine (old Haymaker) and on the northeasterly ore run as far as the Quapaw mine are located on leases of the Emma Gordon Mining Co. and the Commerce Mining & Royalty Co. The production from this part of the Miami district in 1915 amounted to 7, 386 tons of galena concentrates and 21,941 tons of sphalerite concentrates.

The mines on Emma Gordon leases produced about 32 per cent of the galena concentrates, and mines on Commerce leases yielded over 59 per cent of the sphalerite concentrates. The mines on Emma Gordon land that shipped concentrates in 1915 were the Standifer Mining Co., Carson Mining Co. (Oklahoma and Carson mines), High Five Mining Co., Prairie Mining Co., and Lennan Zinc & Lead Co.

The Gartung Milling Co. built a 200-ton mill to treat the tailings at the Prairie mine. This mill was in operation in November. A 200-ton tailing mill was also built by Theurer & Co., at the Carson mine, but it was not completed until January, 1916. The ore mined at the Carson and the Prairie mines was from the 300-foot levels.

The productive mines on leases in the immediate vicinity of Commerce on land of the Commerce Mining & Royalty Co., were the Cactus (Tango shaft), Lost Trail, New State, Mizpah, Queen City-Joplin, Frosty Morning, First Chance, Turkey Fat, King Jack (The Concentrating Co.), Never Sweat, Midas, Old Chief, Miami Amalgamated (Sullivan), and the Eureka, now called the T. H. C. Mining Co. Of these mines the Mizpah, Cactus, King Jack, Turkey Fat, and Never Sweat mines were operated by the controlling interests in the Commerce Mining & Royalty Co. The largest outputs were made from the Mizpah, King Jack, Lost Trail, Amalgamated, and Turkey Fat mines. The Tango mine was developed and equipped with a mill in 1915.

Worley & Co. purchased the Old Chief mill of 200 tons capacity, completely rebuilt the plant, and added 9 tables. This mill was run on tailings from the Old Chief mine after December 1, 1915. The mine will be reopened after the large tailing pile has been re-run.

The Haymaker tract on Commerce land, in the extreme northeastern section of the district, was leased to the Vantage Mining Co. A large output of sphalerite was made from ore mined at about the 200-foot level. The Quapaw and Lennan mines on Commerce land, at the northwestern limits of the town of Commerce, were operated steadily all the year. The deepest mining in the district was at the Lennan mine, where ore was taken from levels as deep as 385 feet.

The mines northeast of Commerce, near Cardin and Picher, and also east of Tar Creek, from which concentrates were shipped in 1915, were the Blue Goose, McConnell, Cornfield, and Admiralty. Mills were built or under construction at several other mines, but no shipments were made in 1915.

Northeast of the Quapaw mine the Blue Bird mine and 150-ton mill on the Cooper & Goodwin land were sold by L. C. Church to the Miami Mines Co. An extensive drill campaign developed large bodies of ore, and several new shafts were sunk from which large quantities of ore were hoisted early in 1916. The Short Horn mine was also acquired by the same interests and a 250-ton mill is to be built.

Northeast of the Blue Bird mine, the Blue Goose mine, belonging to the Commerce Mining & Royalty Co., was opened. This mine, which is equipped with a 200-ton mill, reached a producing basis late in the year, and early in 1916 had become the largest producer in the Miami district. North of the Blue Goose mine is the Beaver mine, at which a 200-ton mill was under construction in December, 1915. Farther east on the west side of Tar Creek the 250-ton mill of the McConnell Lead & Zinc Co. was steadily operated in 1915. The mill shaft at this mine is 218 feet deep, and the northeast shaft, completed in 1914, is 200 feet deep. New Bessemer gas engines were purchased in 1915 and over 3,000 feet of drilling was done on the property.

The Cornfield mine is located about one-third of a mile south of the McConnell mine on the Temple Chapman lease of Commerce land. There are two shafts at this mine and the ore mined was taken from the 145-foot level. This ore was very rich in galena. It is stated that ore bodies at lower levels were shown by drilling done in 1915 and that the two shafts will be sunk in 1916 to reach these ore bodies.

The Croesus mine on the Day Cooter & Co. land is close to the west side of Tar Creek and south of the Cornfield mine. A shaft was sunk

in 1915 and a 200-ton mill built. This mill was operated in December, but no shipments of concentrates were made.

East of Tar Creek the only mine from which concentrates were shipped in 1915 was that of the Admiralty Zinc Co., which purchased the Century lease on the Douthit land. A 150-ton mill was built and operated in 1915. The success of this plant and the location of extensive bodies of ore by drilling will probably result in the owners building other mills on the lease.

Another mine on the east side of Tar Creek opened in 1915 and equipped with a 250-ton mill was that of the Welch Mining Co. on the Mary Calf land leased to L. C. Church. A very heavy flow of water was struck at the mine. Pomona pumps were used for the first time in the district and 4,000 gallons of water a minute were pumped for a long time before the ore body at the 183-foot level could be worked. The ground at this mine is much more open than that farther north on the Picher leases. There are two shafts at this mine and shipments of concentrates were made early in 1916.

The Underwriters Land Co., which has been one of the oldest and largest operators in the Joplin region, leased part of the Portis land northeast of Cardin, and after drilling about 12 holes started sinking two shafts. The draining of the Welch mine removed all trouble from excessive water. A 250-ton mill was contracted for but not completed in 1915.

The 3,000 acres of land controlled by the Picher Lead Co., lying mainly in the territory immediately south of the Kansas State line in the northwestern part of T. 29, R. 23, was the most prominent area of the Miami district. The development work started in 1914 was continued throughout 1915. A new village came into existence, new roads, and other improvements were undertaken, all dependent on and interwoven with the development of the mines in the most northerly section of the Miami district. Many thousands of dollars were expended in drilling, sinking shafts, and the construction of mills, undoubtedly more than that invested by any other company in the Joplin region. One 300-ton mill, known as the Whitebird mill, was completed in November, 1915, and run on ore taken from the 283-foot level at No. 3 shaft. This mill uses electricity for power and is equipped with a separate sludge plant containing a Door thickener, 4 Deister tables, 6 Arbuthnot tables, 1 Henry shaking screen. The ore milled in December averaged about 12 per cent recovery in galena and sphalerite concentrates. The zinc content of the sphalerite concentrates was about 59 per cent, and the lead content of the galena concentrates was about 82 per cent. Shaft No. 1 was down to ore at 283 feet and shafts Nos. 1, 4, 5, 6, and 7 were being sunk. The construction of mill No. 2, called the Crawfish mill, also of 300 tons capacity, and to be similar in construction to mill No. 1, was commenced in December. Several other mills—probably 5 in all on the land—will be built as quickly as the buildings can be erected and the machinery delivered.

It is certain that the Tar Creek and Picher parts of the Miami district will produce a much larger proportion of the output in 1916 than in 1915.

Davis district.—The producing mines in the southern part of Oklahoma are located 8 miles southwest of Davis in Murray County, near the northwest end of the Arbuckle Mountains. The ore deposits are

found in the dolomitic Arbuckle limestone, generally in clay-filled solution channels. The zinc ore occurs as a carbonate from the surface to a depth of 5 to 8 feet. Below this level the zinc is in the form of the sulphide.[1]

Nearly all the ore has been taken from shallow workings and none of the mining properties have been large producers. The first ores were mined in 1909, and small shipments were made in that year and in 1910, 1911, and 1912. The total recorded production of the district has been 558 tons of zinc carbonate, valued at $9,660, and 407 tons of sphalerite, valued at $20,754, of which 132 tons, valued at $9,912, were shipped in 1915.

In 1915 the mines were reopened after having been idle for two years. The old mill of the United Mining & Milling Co. was torn down and the erection of a new one commenced. While this work was in progress, some ore from workings above the 25-foot level were hauled a distance of 1½ miles to the Goose Nest mill for treatment. A new concentrating plant was also erected by the Washita Lead & Zinc Co. and some sphalerite averaging 55 per cent zinc content was shipped. C. L. McGuire had no mill on his land in sec. 21, T. 1 E., R. 1 S., but shipped hand-cobbed ore taken from open cuts 12 feet deep.

It is reported that the cost of hauling concentrates from the mines to Davis was $2.50 a ton and that the freight rate on shipments from Davis to the smelters was $2.25 a ton.

A description of the region, the ore occurrence, and the development of the then existing mines was given in this report in Mineral Resources for 1912.

WISCONSIN.

By J. P. Dunlop.

PRODUCTION.

Production of lead and zinc in Wisconsin in 1915, by districts.

District.	Ore.					
	Lead concentrates (galena).		Zinc concentrates.			
			Sphalerite.		Carbonate.	
	Quantity, short tons.	Value.	Quantity, short tons.	Value.	Quantity, short tons.	Value.
Benton	1,681	$95,712	66,685	$2,080,675	.....	.....
Cuba City	.....	.....	2,145	57,055	.....	.....
Dodgeville	128	6,610	654	39,800	23	$480
Hazel Green	243	10,048	24,847	865,179	.....	.....
Highland	a 68	2,166	118	7,879	2,034	39,643
Linden	390	19,000	7,275	287,401	.....	.....
Livingston	164	7,977	20,070	728,826	.....	.....
Mifflin	307	18,736	8,499	364,459	.....	.....
Mineral Point and Montfort	6	360	81	5,200	522	8,100
Platteville	78	4,282	7,966	365,596	.....	.....
Shullsburg	110	6,200	656	31,246	.....	.....
State total, 1915	3,175	171,091	138,996	5,333,316	2,579	48,223
1914	2,028	85,196	108,535	1,924,126	2,787	38,033

a Includes a small quantity of lead carbonate.

[1] Snider, L. C., Preliminary report on the lead and zinc of Oklahoma: Oklahoma Geol. Survey Bull. 9, pp. 86–90, 1912.

Production of lead and zinc in Wisconsin in 1915, by districts—Continued.

District.	Metal content.[a]			
	Lead.		Zinc.	
	Quantity, short tons.	Value.	Quantity, short tons.	Value.
Benton	1,241	$116,654	19,231	$4,769,288
Cuba City			389	96,472
Dodgeville	96	9,024	300	74,400
Hazel Green	155	14,570	6,973	1,729,304
Highland	35	3,290	481	119,288
Linden	278	26,132	2,430	602,640
Livingston	123	11,562	4,997	1,239,256
Mifflin	241	22,654	3,009	746,232
Mineral Point and Montfort	4	376	158	39,184
Platteville	61	5,734	3,160	783,680
Shullsburg	88	8,272	275	68,200
State total, 1915	2,322	218,268	41,403	10,267,944
1914	1,494	116,532	31,113	3,173,526

[a] In calculating the metal content of the ores from assays allowance has been made for smelting and concentration losses in the case of zinc but not in the case of lead. In comparing the values of ore and metal it should be borne in mind that the value given for the ore is that actually received by the producer and that the value of the lead is calculated from the average daily quotations at New York. The zinc price used for 1915 is the average sales price reported by smelters.

Tenor of lead and zinc ore and concentrates produced in Wisconsin, 1914 and 1915.

	1914	1915
Total crude ore ..... short tons	1,387,490	1,934,000
Total concentrates in crude ore:		
Lead ..... per cent	0.14	0.16
Zinc ..... do	8.02	7.32
Metal content in crude ore:		
Lead ..... do	.11	.12
Zinc ..... do	2.8	2.65
Average lead content of galena concentrates ..... do	73.7	73.5
Average zinc content of sphalerite concentrates ..... do	35.05	36.5
Average zinc content of zinc carbonate concentrates ..... do	27.5	24.9
Average value per ton:		
Galena concentrates	$42.01	$53.88
Sphalerite concentrates	$17.73	$38.37
Zinc carbonate concentrates	$13.65	$18.70

The lead and zinc mines of Wisconsin are in Grant, Iowa, and Lafayette counties and comprise the most important part of the ore deposits of the upper Mississippi Valley region, a historical review of which is given in the Illinois section of this report in Mineral Resources for 1914. A detailed description of the Wisconsin lead and zinc districts and of the mines in each district to the year 1906 is given by Bain.[1] Although mining development has continued and many new mines have been opened, worked out, and abandoned, the area of the mining region has not been enlarged to any extent. The development of the mines subsequent to Bain's report and the output of Wisconsin mines have been given in the reports in Mineral Resources of the United States for the years 1907 to 1913.

The ore deposits occur in the Galena dolomite and in the upper part of the Platteville limestone, both of Ordovician age. The ores

[1] Bain, H. F., Zinc and lead deposits of the upper Mississippi Valley: U. S. Geol. Survey Bull. 294, pp. 81–148, 1906.

are galena, sphalerite or zinc blende, with smithsonite or zinc carbonate, the last locally known as "dry bone." As a lead region the district has been known from the earliest settlement days. In time the building of smelters near by made a market for the zinc ores. The first zinc ore to be mined was the carbonate found in association with lead in the shallow working above ground-water level. When all the main deposits were worked out down to water level there was a lull in mining in the region. Though the carbonate was known to give place to zinc blende and the lead to continue on below water, it was not deemed profitable to mine when continued pumping was necessary. About 8 or 10 years ago the higher price of zinc led to the opening of some of the deposits below water level, since which time zinc mining has increased until Wisconsin ranks among the largest of the zinc-producing States. The ore bodies are found in perpendicular, horizontal, or inclined cavities known as "openings" or "crevices," "flats," and "pitches." The openings sometimes extend for a considerable distance in a straight line called a "range," and may be operated at different places by different companies. When a range is once established it becomes an important guide in prospecting.

The galena of the district is nonargentiferous, and so far as known the zinc ores are free from cadmium. In some of the mines marcasite is so plentiful that the zinc blende concentrates are reduced to a very low grade. Owing to their nearness in specific gravity, marcasite and blende are very difficult to separate cleanly by hydraulic methods. Both electrostatic and electromagnetic separation processes have been used.

Comparatively few of the concentrating plants in the district are equipped with roasters, but practically all the larger mining interests own or control separating plants. In the early part of 1915 it was difficult to sell low-grade sphalerite concentrates to the smelters and the roasting and separating plants in the region were not capable of handling the entire output of raw zinc concentrates. There were few inquiries for low-grade sphalerite, so notwithstanding the high price of zinc a large quantity of these concentrates accumulated at the mines. To remedy this condition several new separating plants were erected in the adjoining galena district and others in Wisconsin.

The roasting and separating plants operated or being constructed in Wisconsin in 1915 were as follows: Linden Zinc Co., at Linden, used to treat the ores from the Optimo mines, and also to treat custom ores; the Campbell Magnetic Separating Co.'s plant at Cuva City, operated by the Wisconsin Zinc Co. until September, 1915, and now taken over by the Linden Zinc Co. Both of these plants use a patented process which requires the ore to be only slightly roasted and which recovers marcasite and pyrite suitable for sale to acid manufacturers. The Empire roaster of the Wisconsin Zinc Co., the Enterprise roaster of the Kistler, Stephens Mining Co., and the Homestead roaster of the Climax Mining Co. are located at Platteville; the Mineral Point Zinc Co.'s plant is at Mineral Point, and the Benton Roaster Co., the Galena Refining Co., of the Field interests, and the Champion roaster, of the Wisconsin Zinc Co., are at Benton. The Mineral Point Zinc Co. was constructing another separating plant at Mineral Point.

The new plants finished or building in Wisconsin and at Galena, Ill., will greatly increase the shipments of roasted concentrates to smelters, for many of these plants are of large capacity and capable of handling the increased yield from the mines.

The multiplication of individual and custom roasters, by raising the low-grade ore to high grade, has a tendency to reduce relatively the quantity of zinc concentrates shipped to smelters, though, of course, the metal content and the value will be less affected; hence these last must serve as the basis of comparison for different years. It is rather difficult to estimate the exact quantity of green ore treated at separating plants, as the Mineral Point Zinc Co. operate an oxide plant and also a separating plant at Mineral Point, and some of the green ore purchased may be used at the oxide works without being treated at the separating works. More than 85 per cent of the sphalerite concentrates shipped from mines in Wisconsin in 1915 went to separating companies or was roasted at the mines before shipment.

A few of the Wisconsin mines produce sphalerite concentrates of such a character that no roasting is required, but the total quantity of such high-grade concentrates is a very small percentage of the production. The increased capacity of the roasting and separating plants will undoubtedly result in very much curtailed shipments of sphalerite having a high iron content.

The average zinc content of the raw sphalerite concentrates sold in 1915 was 36.5 per cent and the average price per ton was $38.37; the corresponding content and price for 1913 were 38 per cent and $21.53, and for 1914, 35.05 per cent and $17.73.

The percentage of concentrates recovered from crude ore is much higher than in the Joplin region, but the zinc concentrates average 20 to 22 per cent less in zinc content. On account of these conditions, at many mines no close recovery is made and the tailings, containing large quantities of zinc, are seldom reworked.

The new concentrating plants are being equipped with more tables than formerly. The concentrates from the tables have usually a very high iron content, but this can be remedied by roasting, so that such concentrates are profitable at the high price paid in 1915.

The crude ore yields from 5 to more than 20 per cent of concentrates. The mining methods are largely determined by the mode of occurrence of the ores, but otherwise are similar to those in vogue in working the pockety ores at Joplin.

The zinc carbonate ore, which is mined principally in the Highland and Mineral Point districts, is purchased mainly by the Mineral Point Zinc Co. and made into zinc oxide in the plant at Mineral Point, Wis.

The metal content of the raw sphalerite concentrates sold by the mines varied in 1915 from 14 to 59 per cent. The larger portion of the concentrates sold ranged between 28 and 47 per cent. The zinc content of the roasted sphalerite concentrates shipped varied from 56.5 to 60.2 per cent.

The value of the mine output of lead and zinc in Wisconsin for the year 1915 was $10,486,212, against $3,291,437 in 1914, an increase of $7,194,775. The total value given for 1914 included that of a small quantity of copper and of silver, neither of which metals were produced in Wisconsin in 1915.

The lead concentrates sold increased from 2,028 tons, valued at $85,196 in 1914 to 3,175 tons, valued at $171,091 in 1915. The sphalerite concentrates sold increased from 108,535 tons to 138,996 tons, and the value of such concentrates increased from $1,924,126 to $5,333,316.

The quantity of zinc carbonate concentrates shipped decreased from 2,787 tons in 1914 to 2,579 tons in 1915, but the value increased from $38,033 to $48,223.

The metal content of the lead concentrates in 1915 was 828 tons more than in 1914. The recoverable zinc content of the sphalerite and zinc carbonate concentrates in 1915 increased 10,290 tons.

During the latter part of the year the mines in the southern part of the mining region were hampered by the inability of the Interstate Light & Power Co. to supply regularly sufficient power to operate the mines and mills. The plant of the power company at Galena was overtaxed to supply the power required by the increased number of operators. Interruptions to the service were numerous, notwithstanding that every effort was made to prevent the loss occasioned by stopping work at mines and milling plants.

The Benton district was much the largest producer of both galena and sphalerite concentrates, its output being almost three times that of Hazel Green, the next largest producing district. The mines in these two districts yielded about two-thirds of the sphalerite and 61 per cent of the galena concentrates shipped by Wisconsin mines in 1915. The districts in Wisconsin which had a smaller production of zinc concentrates in 1915 than in 1914 were Mineral Point, Montfort, Dodgeville, Highland, Hazel Green, and Cuba City. The quantity of ore treated was about 450,000 tons more in 1915 than in 1914, and the quantity of green sphalerite concentrates recovered was 22 per cent larger than in 1914. The average zinc content increased from 35.05 per cent in 1914 to 36.5 per cent in 1915, and the average price per ton paid for sphalerite increased $20.64 a ton. The average zinc content of the carbonate concentrates decreased, although the average price increased $4.05 a ton, but no fair comparison is possible, for the shipments in 1914 and 1915 included a large quantity of low-grade waste and sludge shipped from the Franklin and other mines at Highland. The galena concentrates sold in 1915 had a slightly lower lead content, and the average price was more than $10 greater than in 1914.

The larger mining interests in the field, which include the Mineral Point Zinc Co., Wisconsin Zinc Co., Vinegar Hill Zinc Co., Cleveland Mining Co., Frontier Mining Co., and Field Mining & Milling Co., had a combined output approximately equal to 63 per cent of all the lead concentrates and 83 per cent of all the zinc concentrates shipped from Wisconsin mines in 1915. These same companies shipped 61 per cent of all the lead concentrates and 85 per cent of all the zinc concentrates in 1914. New interests represented by Saxe, Pollard & Co., of Milwaukee, and Utt, Thorne & Co., of Platteville, were very active in leasing old properties and opening new mines, so that their production will be a substantial part of the output in 1916.

The new development work done, the new producing mines, the new mills, and the transfers of ownership are set forth under the reviews by districts. For descriptions of the old mines and con-

centrating plants on which no essential changes were made during 1915, the reader is referred to the corresponding section of this report in Mineral Resources for 1913 and 1914.

REVIEW BY DISTRICTS.

Benton district.—The Benton district produced about 53 per cent of the galena concentrates and 48 per cent of the sphalerite concentrates sold in Wisconsin in 1915. The quantity of galena concentrates was 974 tons more and that of zinc concentrates 20,816 tons more in 1915 than in 1914. The total value of all concentrates sold in 1915 was $2,676,387, against $792,209 in 1914. In addition to the shipments of lead and zinc concentrates about 4,600 tons of marcasite were shipped. More new properties were developed and equipped in this district (with which are included the mines in that section called New Diggings) than in any other part of the upper Mississippi Valley region.

Several new mines were operated with local capital and some outside capital was invested in the district, but the increased production and development was mainly due to the extension of operations by the large companies.

The largest quantity of sphalerite concentrates was shipped from the Champion, Martin, Fox, Grotkin, and Crawhall mines in the order named. As the zinc content of the sphalerite shipped from the district was as low as 19 per cent and as high as 48 per cent, the rank of the principal producing mines, according to value of output, was as follows: Champion, Grotkin, Crawhall, Martin, and Calvert.

One of the largest and most complete surface plants in the district was completed by the Field Mining & Milling Co. at the Thompson mine. The new concentrating plant, finished in August, has a capacity of 35 tons per hour. The mill is electrically driven and is equipped with many innovations for the district, including a Dorr thickener and sludge tables. The jigs are arranged in parallel lines and it is stated that this has resulted in an increased recovery of concentrates amounting to 15 per cent. The Crawhall mine and 20-ton (per hour) mill were also steadily operated and two drill rigs were used for exploration work. The Galena Refining Co., which is a subsidiary company of or affiliated with interests represented in the Field Mining & Milling Co., constructed at New Diggings a roasting and separating plant having a capacity of 25 tons daily. This small plant was built chiefly as an experiment and was considered so efficient that a similar plant having a capacity three times as large was built at Galena, Ill.

The Acker Mining Co. continued drilling on the Gray land and sunk a prospect shaft. No output was made other than a small quantity of galena.

The Frontier Mining Co. was one of the largest shippers in the district. Ore was mined from the Grotkin and Calvert leases at the 150-foot level, and the Bull Moose shaft on the Grotkin land was sunk 10 feet deeper. On the Calvert lease a new range was located which strikes approximately east. This range was worked for more than 300 feet in 1915. The only development on the Robson lease was the drilling of three holes northwest of the Frontier mine.

The shaft at the new Hird mine was sunk in broken ground and much of it had to be lined with concrete. A large quantity of water

was encountered which made the sinking of the shaft very slow and difficult. There was no output from the mine in 1915, but it has been fully equipped and will be a large producer in 1916. The Brookside Milling Co., on the Calvert lease, was one of the few tailing mills operated in Wisconsin.

Some ore was mined at the Kearns mine of the Grand View Mining Co. and concentrated by means of hand jigs. The Indian Mound Mining Co. on the Monroe land at New Diggings opened its mine and operated the mill for about six months, making a good yield of both lead and zinc concentrates.

A large production was made at the Fox and Penna-Benton mines of the Mineral Point Zinc Co., the latter mine having been developed late in 1914 and equipped with a mill. There were no new developments reported at these mines. The new Eureka mine was leased by the Wisconsin Zinc Co., and a drift was being driven from the Champion mine to the old workings, a distance of about 700 feet.

The largest output of galena concentrates in Wisconsin and one of the largest of sphalerite was that of the Vinegar Hill Zinc Co. from the Wilkinson, Martin, and Kittoe mines. The Wilkinson is under lease to the K. C. & M. Mining Co., which is building a new 75-ton mill. The Martin mine, which is equipped with a 200-ton (10-hour) mill, was steadily operated, having a production second only to that of the Champion mine. New equipment was installed at the Kittoe mine, including a concentrating plant which had a large production after it was completed. Twenty-seven holes were drilled at the Blackstone mine on the Kelley land and a new mill was under construction. The 75-ton mill of the Longhenry Bros. Mining Co. on the Spenceley land was finished and some ore taken from an 84-foot shaft was milled.

The Champion mine of the Wisconsin Zinc Co. had the largest output of sphalerite in Wisconsin. This mine was opened in 1914 and equipped with a 300-ton (10-hour) mill. A sludge plant containing 8 Wilfley tables was added in 1915.

The mill at the Winskill mine was rebuilt and new machinery installed. The C. A. Thompson land was drilled, a 160-foot shaft was sunk, and a 200-ton mill was contracted for. A shaft 125 feet deep was sunk on the J. M. Thompson land by the Wisconsin Zinc Co. in 1915, but the lease did not produce any ore.

The Burr Mining Co. drilled the Triganza lease for 400 feet on an east and west range. As the drilling disclosed good bodies of ore, a 160-foot shaft was sunk and the erection of a concentrating plant was begun. The old Mathey plant, a quarter of a mile south of Benton, was purchased by the Benton Roaster Co. The plant was completely rebuilt, and large expense was incurred in the installing of Dings separators and other machinery. Low-grade concentrates from the Biddicke and other mines will be treated.

The opening of the various new mines in the New Diggings section was delayed by bad roads. After efforts had been made to have a spur built from the Chicago & North Western Railway at Benton to New Diggings, a macadamized road 4 miles long was constructed.

Cuba City-Elmo district.—The production of lead concentrates in 1915 in this district was 20 tons less than in 1914, and that of sphalerite was 119 tons less than in 1914. Most of the output in 1915 came from the Lawrence mine of the Utt Thorne Mining Co. The mine was reopened in July and the old 100-ton concentrating plant

repaired. The ore mined was taken from the ore bodies between the 75-foot and the 85-foot levels.

The Big Eight Mining Co. leased the Raisbeck and Gritty Six mines and developed some new ground. Some hand-cobbed high-grade sphalerite was shipped by Anthony & Co., which was from ore mined at the 50-foot and 85-foot levels. A small quantity of custom ore was also milled at the old Roosevelt mill by the Dominion Mines Co. before the lease was given up. The Midway and Best mines of the Long Range Mining Co. were not operated in 1915.

The capacity of the plant of the National Zinc Separating Co. was increased from 60 tons to 100 tons daily, and it was operated steadily in order to handle the increased shipments of raw concentrates. The plant is now equipped with 4 Mathey kilns and 13 Dings magnetic separators.

Dodgeville district.—The production of lead concentrates increased in this district from 12 tons in 1914 to 128 tons in 1915, and the output of sphalerite decreased from 705 tons in 1914 to 654 tons in 1915. The Lucky Five Mining Co., on the Davis land and the Thomas land, was the largest producer of both lead and zinc concentrates. The Treweek shaft at this mine is 96 feet deep, the Davis shaft 90 feet, and the concentrator has a capacity of 50 tons. Some prospecting was done and a new shaft was sunk at the Henry T. Roberts mine, on the Berryman land. Other shipments of galena, sphalerite, and zinc carbonate were made by D. & G. Williams, Thomas Harney, Evans Bros., Carroll Guthrie, Davey & Evans, and L. Enoch.

Hazel Green district.—Although there were only four producing properties in this district in 1915, the production of lead concentrates was 243 tons and that of sphalerite concentrates was 24,847 tons. The district ranked second in point of production in Wisconsin in 1912, 1913, 1914, and 1915. The quantity of both lead and zinc concentrates shipped in 1915 was about the same as in 1914. The Kennedy mine of the Mineral Point Zinc Co. was the largest shipper of sphalerite, but the value of its production was about equal to that of the Cleveland Mining Co. There were no special changes in the operation or equipment of the Kennedy, Cleveland, or Federal mines. The Lawrence mine, equipped in 1914, was a large producer, and the Dinsdale mine, taken over at the end of the year by the owners of the Lawrence, was to be opened and the mill repaired.

The Monmouth Zinc Mining Co. leased the Barrett land and drilled 21 holes, locating good bodies of ore. A shaft, which is to be 207 feet deep, was being sunk and the construction of a 100-ton mill was begun in October, 1915.

The shaft of the McMillan Mining Co., on the Pearce land, was sunk 157 feet. The heavy flow of water made sinking very difficult, and the 100-ton mill was not operated in 1915.

Highland district.—The Mineral Point Zinc Co. controls most of the mining lands in this district and owns a mill of large capacity at the Highland mine. The only other concentrating plant in the district is a small one on the St. Anthony Mining & Milling Co.'s land. The shipments in 1915 of all classes of concentrates were less than in 1914, and during a large part of the year there was little demand for low-grade zinc carbonate. The concentrates sold were, as usual mainly composed of zinc carbonate, but some high-grade, hand-jigged sphalerite was sold by Lampe & Steppler and by Miller, Kent

& Williams. All of the ore mined is derived from levels above 100 feet, and most of the shafts are less than 60 feet in depth.

The producing leases on the St. Anthony land were those of Mulderney & Gunn, Chaney & Co., and Winken Bros. Other producers were the Web King Mining Co. and Blue River Mining Co., on the Beran land. No mining was done at the Highland mine and the carbonate shipped was from old dumps and sludge piles.

Linden district.—In 1915 the production of galena concentrates decreased 179 tons and that of sphalerite increased 805 tons when compared with the production in 1914. Optimo No. 2, on the Smith land, first operated in 1913, was the largest producer of sphalerite in the Linden district. The mill at this mine has a capacity of 100 tons and is operated by electric power. Optimo No. 2 was abandoned, and the erection of a 200-ton mill on Optimo No. 3 was begun in September, 1915.

The Campbell patented process is used at the plant of the Linden Zinc Co., which treated green concentrates from the Optimo and other mines. The capacity of the plant was doubled and the grade of the roasted concentrates increased to more than 60 per cent zinc content.

Ross Bros. sold the largest quantity of galena concentrates and the second largest quantity of sphalerite concentrates in the district in 1915. The shaft at this mine is 100 feet deep, and the concentrating plant has a capacity of 60 tons.

The Heathcock land was drilled by C. W. Singer, and a new company called the Hillside Spring Mining Co. put down a shaft on the lease. Sphalerite concentrates were shipped by A. Launder and also by the Stoner Mining Co. and the J. P. Williams Co. leases on Ross Bros.'s land. A 75-ton mill was built at the Stoner mine, but no ore was treated at this mill in 1915.

The Glanville mine was taken over by the Saxe Pollard Development Co., and a large quantity of concentrates were shipped. The same company also acquired the Gilman mine and equipped it with a 150-ton plant, which was not operated until January, 1916. The Weigle mine also is reported to have been leased to the Saxe Pollard Development Co. The Hinkle mine, after being idle for two years, was reopened by the Linden Development Co. late in the year and the 100-ton mill run on ore taken from the 90-foot level.

Livingston district.—The production of sphalerite in this district increased from 16,347 tons in 1914 to 20,070 tons in 1915, and the district was again the third largest producer of sphalerite in Wisconsin.

Coker No. 1 mine of the Mineral Point Zinc Co., which was the largest producer of both lead and zinc, was operated steadily throughout the year. Coker No. 2 mine, opened in 1914, also made a large output. Ore from the Ellsworth and the Rundell mines of the Vinegar Hill Zinc Co. was hoisted from separate shafts and milled at the 200-ton Ellsworth mill.

Mifflin district.—The output of Mifflin district in 1915 was 307 tons of galena concentrates, valued at $18,736, and 8,499 of sphalerite concentrates, valued at $364,459. The shipments of galena in 1915 were 251 tons more than in 1914 and those of sphalerite increased 1,584 tons.

Practically all of the old mines were producers in 1915. The power used at the Grunow was changed from gasoline to electric. The

Peacock mill on the Jenkins land was operated successfully on ore taken from the 95-foot level through 3 shafts. Both roasted and raw sphalerite concentrates were sold by the B. M. & B. Mining Co., operator of the Biddicke mine. The 50-ton mill was started in June, 1915, and part of the raw concentrates were roasted at the Benton Roaster Co.'s plant at Benton.

The old Senator mine was sold to the Hump Mining Co. in October, 1915, and preparations were made to reopen the property. The Shamrock mine on the Ross land, another old property, was also worked once more under the direction of J. Mahoney, and had a good production from ore mined at the shallow depth of 26 feet.

The Peni mine, which is also on Ross land, was mined by the Royal Mining Co. The sphalerite concentrates recovered from this property averaged 51 per cent zinc content, the highest in the district. The ore body, which lies at a depth of 80 feet, was mined through a tunnel. No perpendicular or inclined shafts were utilized as is usual in Wisconsin mines producing sphalerite from ore mined at such a depth. The Slack mine was idle, though it was reported that some old tailings were milled. The power used at the 75-ton mill situated at the Squirrel mine of the B. M. & B. Mining Co. was changed from steam to electric. The concentrates produced were high grade for this district.

The Lucky Six mine, one of the largest producing mines in the district, is equipped with two 80-foot shafts, only one of which was used in 1915. The old 50-ton concentrating plant was used only to remill old tailings and a new 100-ton electrically driven mill was built and used in milling ore hoisted from the mine. The rock broken at this mine is culled underground and the waste is piled up, confined by timbers, and used to support the roof of the drifts.

One of the small shippers of sphalerite was the Phoenix Mining Co., which sold a considerable quantity of sphalerite concentrates of good grade.

Mineral Point district.—All the concentrating plants in this district were idle in 1915, and the only production was that made by a number of small operators. Part of the concentrates came from that section of the district known as Barreltown, and the output was purchased by the Mineral Point Zinc Co. The average zinc content of the ore shipped was less than 30 per cent. The largest producers in 1915 were A. Doney, John Grange, Kindsman & Davis, Perry & Mitchell, Kindsman & Quick, Bray & Stratman, Paulus & Co., B. & J. Bray, Mitchell & Sons, H. Schaaf, Grange & Harvey.

The roasting and separating plant of the Mineral Point Zinc Co. treated more raw sphalerite concentrates than any other plant in the Wisconsin-Illinois region. Mathey roasters and Dings separators were used and the roasted concentrates shipped had an average zinc content of 55.71 per cent.

Montfort district.—The shipments of sphalerite concentrates in 1915 were much less than in 1914. The O. P. David was idle most of the year, and shipments were not made until December. The property was taken over by the Montfort Development Co., and mining was resumed after the surface equipment was repaired. The ore, which is of good grade, was hoisted by means of two shafts, each 127 feet

deep, and was concentrated at a 60-ton mill. The Red Jacket mine of the Mineral Point Zinc Co. and the Nagle mine were both idle.

Platteville district.—The mine production of this district in 1915 was three times as large as it was in 1914, amounting to 78 tons of galena concentrates and 7,966 tons of sphalerite concentrates. The increase was not due to the discovery of new mines, but to the more extended operations at old mines. About one-third of the sphalerite was produced from the East End mine of the Wisconsin Zinc Co., and the remaining two-thirds from the Hodge, Homestead, Klar-Piquette West Hill, Star, Wilson, and Kistler properties.

The Ben Webster Mining Co. lease, on the Hodge mine in the city of Platteville, was transferred to the Vinegar Hill Zinc Co., and the mine and reconstructed mill were steadily operated after October.

The Climax Mining Co. started operations at the Homestead and Acme tracts in June. The property was unwatered and new tubular boilers were installed at the 150-ton milling plant. Roasted sphalerite concentrates and galena were shipped after September, 1915.

The Klar-Piquette mine, which for many years has been one of the best producers in the district, was actively worked. The sphalerite concentrates recovered at the 75-ton mill were treated at the Homestead roaster before shipment.

The ore milled at the East End mine was from the lease on the Seitz land. A new 125-foot shaft was sunk and a tramway built connecting this shaft with the 200-ton concentrating plant. The raw concentrates were roasted at the Empire roaster belonging to the company. This plant will probably be dismantled.

The Kistler Stephens Mining Co. rebuilt the Enterprise roaster and separator and also operated the Alderson tract. The output of roasted sphalerite was large. The Star Mining Co., closely affiliated with the Kistler Stephens Mining Co., reopened the old Grant County mine from which ore was mined and milled late in the year. The raw sphalerite was roasted before shipment.

The West Hill Mining Co.'s lease on the Stephens and Hill lands, first developed late in 1914, was actively worked. The 50-ton mill made a good recovery from ore mined at the 110-foot level and the sphalerite shipped had an average zinc content of 55.2 per cent.

A new corporation called the M. & H. Mining Co. developed a mine on the Loomis land, and a 100-ton mill was built. This mine and mill had no output until early in 1916.

Only development work was done by the Bell Mining Co. on the Graham Stephens Mining Co.'s land and by the Black House Mining Co. at the Cruson mine. New ore bodies were located at the Cruson and the necessary equipment was being installed.

A 180-acre tract of the Quincy land and other leases were drilled by a new company called the Quincy Mining Co. The drilling did not result in any actual mining.

The old Preston Point mine at Potosi, owned by the Wilson Mining Co., was again operated. A new shaft was sunk and other improvements were made. The mine was a good producer of high-grade sphalerite during the last part of 1915.

Shullsburg district.—The shipments of galena concentrates from this district increased from 62 tons in 1914 to 110 tons in 1915 and those of sphalerite from 446 tons to 656 tons. The only producing

mines were the Rodham and the Milwaukee-Shullsburg, which were operated intermittently.

The Milwaukee-Shullsburg mine, on the Rowe land, was leased part of the year to Frank Rowe and later subleased to Ralph Davis. Tailings were milled and a small amount of development work was done in 1915.

The production of lead and zinc concentrates by the Rodham Mining Co. was less than usual but considerable drilling was accomplished during the year. The Mulcahy tract was drilled by the Oliver Mining Co. and shaft sinking was commenced. It is probable that mining will be more active in this camp in 1916.

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[1] The publications for which a price is given are no longer available for free distribution but can be purchased from the Superintendent of Documents, Washington, D. C., others can be obtained free on application to the Director of the United States Geological Survey. Some are out of print but may be examined in libraries.

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PLATINUM AND ALLIED METALS.

By James M. Hill.

DOMESTIC PRODUCTION.

CRUDE PLATINUM.

The production of crude platinum in California and Oregon in 1915 was 741.91 troy ounces, having a value of about $23,500. This was an increase of 171.91 ounces over the production in 1914. Most of the crude platinum came from California; only one mine in Oregon reported a production in 1915.

The Rambler mine, Albany County, Wyo., produced platinum-bearing copper concentrates, which were shipped to eastern refiners.

REFINED PLATINUM.

According to the reports received from the refiners of platinum, gold bullion, and blister copper, 8,665 troy ounces of refined new metals of the platinum group were recovered, of which 1,587 troy ounces are believed to be of domestic origin.

New platinum and allied metals recovered by refiners, 1914–15, in troy ounces.

Year.	Platinum.	Iridium.	Iridosmine-osmiridium.	Palladium.
1914	3,430	64	195	2,635
1915	6,495	274	355	1,541

These figures are not as complete as could be desired, and are probably several hundred ounces below the actual production. The platinum situation has been so disquieting during 1915 that refiners have been loath to give much information either as to the sources from which their supplies have been derived or as to the actual results of their operations. It is hoped, however, that another year will see more stable conditions.

Aside from the output of new metal of the platinum group, a large quantity of secondary metal derived from the refining of scrap and sweeps was sold. The figures given below are tabulated from replies received from the refiners and appear to show, when taken in conjunction with the figures of production of new metals and of imports, the total quantity of platinum and allied metals necessary to supply the domestic market. It must be realized that figures of sales of scrap metal contain some duplications, for scrap, especially from

jewelry and dental works, may be refined and sold several times during the year.

Secondary platinum and allied metals sold in 1914–15, in troy ounces.

Year.	Platinum.	Iridium.	Iridosmine.	Palladium.
1914	40,698	129	18	1,500
1915	42,149	863	.....	958

WORLD'S PRODUCTION.

Figures of the world's production of platinum and allied metals are at best estimates made from the most reliable information obtainable. The figures in the table below for 1915 for Russia, Colombia, New South Wales, and Tasmania are based on figures supplied by the American consular service, revised in connection with other information at the disposal of the Geological Survey.

Estimated world's production of crude platinum in 1912–1915, in troy ounces.

Country.	1912	1913	1914	1915
Borneo and Sumatra	200	200	(a)	(a)
Canada	30	50	30	100
Colombia	12,000	15,000	17,500	18,000
New South Wales and Tasmania [b]	778	1,275	1,248	303
Russia	300,000	250,000	241,200	124,000
United States	721	483	570	742
	313,729	267,008	260,548	143,145

[a] No basis for estimate. [b] Tasmania, osmiridium.

IMPORTS.

Notwithstanding the embargo placed upon the exportation of platinum by all the allied governments, the imports of platinum and allied metals into the United States during 1915, as compiled by the Bureau of Foreign and Domestic Commerce, Department of Commerce, were only 10 per cent below imports in 1914, as will be seen from the following table.

Platinum and allied metals imported for consumption in the United States, 1914–15.

Metal.	1914		1915	
	Quantity (troy ounces).	Value.	Quantity (troy ounces).	Value.
Platinum or crude platinum and unmanufactured products, ingots, bars, sheets, wires	[a] 72,032	[a] $2,934,080	61,438	$2,341,476
Platinum, manufactured products, vases, reports, etc.	(b)	46,533	(b)	73,799
Iridium	1,785	112,430	4,158	243,266
Osmiridium	1,348	84,363	130	5,737
Osmium	.....	.....	32	787
Palladium	1,613	69,547	3,020	103,623
Rhodium	32	1,905	.....	.....
	76,810	3,248,858	68,778	2,768,688

[a] Revised figures. [b] Quantity not given.

Of particular interest in connection with the imports during 1915 is the source of our foreign supply. As will be seen from the following table, compiled from the records of the Bureau of Foreign and Domestic Commerce, England and France supplied the great bulk of platinum imported by the United States in 1915. It is reported that large quantities of platinum from these countries were sent direct to domestic makers of war munitions for foreign countries, and did not enter the American market. The imports from Canada and Colombia appear to have been largely crude placer platinum, and it is believed that these figures represent nearly the entire output from those platinum-producing countries, though the quality reported from Panama may also have originated in Colombia.

Platinum imported duty free in 1915.

	Unmanufactured.		Ingots, bars, etc.		Manufactured products, vases, etc.	Total. value.
	Quantity (ounces).	Value.	Quantity (ounces).	Value.		
France	14,925	$540,388	3,022	$142,945	$49,654	$732,987
Germany	496	22,659	11	436	855	23,950
Italy					4,665	4,665
Netherlands			53	2,346	483	2,829
Norway	302	11,500				11,500
Spain	1	22				22
England	23,983	930,872	1,919	87,456	15,265	1,033,593
Canada	99	3,528	223	10,479	610	14,617
Panama	105	3,600				3,600
Colombia	15,818	564,967	480	19,278		584,245
	55,729	2,077,536	5,708	262,940	71,532	[a] 2,412,008

[a] Does not include manufactured platinum upon which 50 per cent duty was imposed.

MARKET.

Since September, 1915, when the embargo on exports of European platinum became effective, the American platinum market has been most uncertain. None of the dealers appeared to know where their next supplies were coming from and were reluctant to quote prices. Scrap metal from all sources and even jewelry are said to have found ready buyers among the users of platinum.

The receipt of practically the whole output of Colombian platinum in the United States does not appear to have materially eased the situation. There has been a great demand from the sulphuric-acid industry and from makers of other war munitions who use platinum. The jewelry trade has evidently felt the strain, though a fair demand for platinum settings was reported late in 1915. The report that the National Jewelers' Board of Trade had prepared a bill for the New York Legislature concerning the marking of pure platinum has been denied.[1] Apparently the situation in England is not much better than in the United States, for on January 2, 1916, the ministry of munitions began an active campaign to ascertain the possible reserves of platinum in England.[2] This took the form of a demand on all jewelers and others to supply within three days a statement showing quantity of platinum in bulk, platinum in process of manufacture, and platinum in finished articles.

[1] Metal Industry, vol. 14, p. 80, February, 1916.
[2] Manufacturing Jeweler, London, vol. 58, p. 394, 1916.

PRICES.

REFINED METALS.

As will be seen from the table below, the average price of platinum for several years shows a rather uniform increase up to 1913, when a slight decline took place. In 1914 the price regained a high level of about $45 an ounce, which decreased during the first part of 1915 to $38 in June and July. In September when it was realized that supplies from Europe would be difficult to obtain, prices naturally responded. The high level, $85.50 in December, 1915, has been surpassed during the first months of 1916, and there seems little likelihood of any immediate return to normal conditions. Quotations for 1915 given in the journals are nominal and all sales appear to be subject to negotiation.

Average prices of platinum per troy ounce in the New York market, 1910–1915.[1]

1910	$32.70	1913	$44.88
1911	43.12	1914	45.06
1912	45.55	1915	49.63
January	$41.10	July	$38.00
February	40.00	August	39.25
March	39.50	September	50.00
April	38.63	October	54.50
May	38.50	November	62.63
June	38.00	December	85.50

Prices reported for the refined metals of the platinum group, by different companies, have varied widely during 1915, but what seem to be fair average values are given in the table below, which values have been used by the United States Geological Survey in all computations:

Average price per troy ounce of refined metals of the platinum group, 1914–15.

Metal.	1914	1915
Platinum	$45	$55
Iridium	65	83
Iridosmine	33	35
Palladium	44	56

No prices of osmium, rhodium, and ruthenium are available.

CRUDE PLATINUM.

Domestic.—Prices received by miners in California and Oregon for crude platinum in 1915 ranged from $28 to $38 an ounce, the highest price being paid for platinum recovered by dredges. The Survey has been informed by some miners that the prices offered are so unsatisfactory that they do not care to undertake the saving of the metal.

Colombia.—Colombian crude platinum was sold at $36.75 per ounce from January to March, 1915, the price gradually declining through the summer to $33.25 an ounce in September, when a rise

[1] Eng. and Min. Jour., vol. 101, p. 46, Jan. 8, 1916.

began, the price being $55 in October, $72 in November, and $100 in December.

Russian.—Russian crude platinum, 83 per cent metal, sold for approximately $30.30 an ounce at Petrograd and $30 an ounce at Ekaterinburg during the first five months of 1915. The price for the next three months was $32.25 and $31, respectively, at these markets, and in December the quotations were $56.40 at Petrograd and $56.25 at Ekaterinburg.

NOTES ON THE PLATINUM MINES.

UNITED STATES.

GENERAL STATEMENT.

As is well known, a large part of the new platinum produced in the United States is recovered in the electrolytic refining of blister copper. An article by Eilers [1] shows that blister copper smelted in plants at Garfield, Utah; Omaha, Nebr.; Mountain, Cal.; and Tacoma, Wash., carry from 0.342 to 1.825 ounces platinum and from 0.607 to 4.402 ounces palladium per 100 tons of blister copper treated. The ores smelted by these plants are largely from the Great Basin region, the Rocky Mountain region, California, and Alaska. Evidence collected by the Survey seems to indicate that copper ores from Arizona and Montana do not carry more than traces of platinum, though refiners of blister copper from these sections recover some platinum. Metals of the platinum group are recovered by the refineries of the United States Mint at San Francisco, Denver, and New York, from gold bullion, scrap metals, and sweepings. A statement of the Director of the Mint [2] in this regard is of particular interest to those engaged in the platinum industry, and is quoted in full.

> A distinct achievement of the mint service in the fiscal year 1915 was the melting and spinning of platinum for use in the many Government laboratories.
>
> This metal is recovered in the electrolytic refineries only from the various kinds of bullion deposited. The quantities contained in individual deposits are very small; in practically every instance it is too small to be detected in assaying, and we could not, therefore, compensate the depositor for it, even if the law permitted payment for other than the gold and silver contents of bullion. Furthermore, as bullion of all classes is massed and melted before it passes through the refinery, it would be impossible to determine what particular class carries this metal. In rare cases, where it i evident that a deposit contains platinum the depositor is so advised and is at liberty to withdraw his deposit.
>
> It has been the policy of the Government to sell this rare metal from time to time to the highest bidder, but owing to the fact that Russia, the largest producer of platinum, has curtailed its exportation and thereby caused a marked advance in the price, I have decided to hold so much of the metal recovered as shall be needed for use in the laboratories of the several departments of the Government.
>
> During the past few months equipment has been placed in the New York assay office for melting this metal and the mint at Philadelphia has perfected machinery for spinning it and manufacturing it into utensils used in the laboratories of the Government institutions.

ARIZONA.

Reports have recently been received that the placer gravels of San Domingo district, Yavapai County, and the Plomosa district, Yuma County, carry some platinum as well as gold. The few samples of

[1] Eilers, A., Notes on the occurrence of some of the rarer metals in blister copper: Am. Inst. Min. Eng. Trans., vol. 47, pp. 217-218, 1913.

[2] Woolley, R. W., Director Mint Rept. for year ending June 30, 1915, p. 9, 1915.

placer concentrates from these localities received at the Survey do not contain platinum; yet they are so few in number and so small in size that they can not be said to prove or disprove the absence of platinum in those placer gravels. Day's [1] work showed the presence of platinum in concentrates from near Columbia and Prescott, in Yavapai County. It is also reported that the gravels of Colorado River carry platinum as well as gold. These placers have been worked in places. The largest accumulations of gravels appear to be below the mouth of the Grand Canyon and to extend from Grand Wash for several miles below the mouth of Virgin River.

CALIFORNIA.

Placer mines in Butte, Humboldt, Plumas, Sacramento, Stanislaus, Trinity, and Yuba counties produced over 600 ounces of crude platinum in 1915. The greater part of this output was made by dredges, but some platinum was recovered by hydraulic mines and a small quantity from beach deposits. As stated elsewhere in this report, it is believed that, with adequate provision, the placer deposits of California are capable of producing much more platinum than they do.

NEVADA.

The Boss mine, near Good Springs, Clark County, Nev., was developed for the first 11 months of 1915 by the Platinum Gold Mining Co. under option. Owing to a provision of the contract, no platinum ores were marketed during the operations of this company. On December 1 the property reverted to the original owners, the Boss Mine Co., which reported that a considerable quantity of platinum ore is blocked out and that active development will continue. It is said that platinum ore has been developed to a vertical depth of 150 or 200 feet on the dip of the ledge. Experiments are now under way to develop a method of treatment to separate the platinum-bearing minerals from gangue and copper ores.

OREGON.

Only one mine in Oregon reported a production of platinum in 1915. This is on a beach deposit located in Curry County. Platinum is known to occur in other beach deposits on the southern coast and also in the vicinity of Kerby in Josephine County.

WASHINGTON.

Samples of placer concentrates said to have been obtained from the south fork of Lewis River in Clark County, Wash., have been received by the Survey, in which there is an appreciable quantity of plantinum and gold. This is of particular interest, as it indicates that the older metamorphic series must rise abruptly to outcrop on Lewis River. These earlier rocks are entirely covered by the Columbia River lava only a few miles south of this region.

[1] Day, D. T., and Richards, R. H., Black sands of the Pacific slope: U. S. Geol. Survey Mineral Resources, 1905, pp. 1180–1181, 1906.

WYOMING.

The Rambler mine, near Holmes, Albany County, Wyo., was operated during the entire year by the Platinum Mining & Milling Co. Several hundred tons of copper concentrates carrying platinum and palladium were produced and were refined in Eastern plants.

FOREIGN.

CANADA.

British Columbia.—In the Tulameen district tributary to Revelstoke there appears to have been more placer mining during the latter part of 1915 than for some time, owing to the high price of platinum.[1] The Canadian Department of Mines[2] gives an output of 20 ounces of platinum for 1915, but it is believed that part of the territorial output finds its way into the hands of American refiners and that the production was larger; in fact it is believed that approximately 100 ounces of crude platinum from this district were refined in the United States.

Ontario.—As is well known, the Sudbury nickel-copper ores carry both platinum and palladium, which are recovered as by-products in the electrolytic refining of the blister copper. The refining has up to the present been done in the United States, but the International Nickel Co., owners of both mines and refinery, are reported to have agreed to erect a refinery in Canada. It has recently been reported that a workable deposit of platinum has been discovered in Munro Township, in the northern part of Ontario.[3]

COLOMBIA.

According to figures compiled by the United States vice-consul at Cartagena, 10,046 troy ounces of crude platinum were invoiced at that port and 74 troy ounces at Barranquilla for shipment to the United States in 1915. It is known also that at least one large company—which ships by way of Buenaventura—was a producer in 1915, but no definite information of this company's output is available for publication. From the best information available to the Survey it is estimated that 18,000 troy ounces were produced in Colombia in 1915.

Dr. Tulio Ospina, director of the School of Mines, Medellin, Colombia, in a paper before the Second Pan American Scientific Congress, Washington, D. C., January 3, 1916, outlined the geologic relations of the platinum deposits of his country. According to him the gold-platinum alluvial deposits cover an area of more than 5,000 square miles, which lies west of the central ridge of the Colombian Andes, in the Atratro and San Juan drainage basins, and extends south of the mouth of San Juan River along the coast to Mira River. The richest deposits and those most worked in the past are near the headwaters of San Juan River, principally on Condoto River. The platinum is found in greatest abundance in the present stream channels, but it is also found in conglomerates of Tertiary age. The

[1] Canada Min. Jour., vol. 36, pp. 737–8, December, 1915.
[2] Preliminary report on the mineral production of Canada, p. 15, Canada Dept. Mines, 1915.
[3] Eng. and Min. Jour., vol. 101, p. 161, Jan. 15, 1916.

Tertiary conglomerates appear to have been laid down in a basin whose upper surface is now about 1,600 feet above sea level. Platinum is found in the streams only where the conglomerate has been eroded; stream beds above the areas underlain by that formation are barren. The stream deposits are reconcentrations from the older gravels. The tertiary conglomerate is composed of rounded bowlders of basic rocks, among which diabase, melaphyre, peridotite, and dunite have been recognized. The bowlders were derived from the breaking down of a series of rocks of Jurassic and Triassic age, which are of widespread occurrence on the western side of the middle Andean Range. In the gravels of the San Juan drainage there are about equal quantities of gold and platinum, but in the Atrato basin platinum constitutes approximately 15 per cent of the value, the remainder being gold.

The most productive area is held by English and American capital. What appears to be a conservative estimate gives a total of 336,000,000 cubic yards of gravel that can be considered as reserves, with 68,000,000 cubic yards as proved ground capable of producing at a profit under present working conditions. It is well understood that prospecting in the Choco is difficult and this estimate of reserves may be revised in the light of future work.

The Anglo-Colombian Development Co. completed a dredge on Condoto River in July, 1915, which operated for some time. That the enterprise was successful seems to be indicated by press notices[1] to the effect that more dredges are contemplated and that a preliminary survey is already under way for the development of electric power.

Information concerning the platinum deposits of Atrato River has recently been received by the Survey, which indicates that there are considerable areas from the headwaters to a point below Bete that might well repay more thorough prospecting. In the samples of gravels from the vicinity of Quibdo received by the Survey gold is much more abundant than platinum, but there appear to be sufficient quantities of platinum to be of interest.

NEW SOUTH WALES.

According to reports received from the United States consul at New Castle, Australia, 56 ounces of platinum, valued at $2,316, was produced in New South Wales in 1915, as against 244 ounces in 1914. The platinum is found in the gold placer deposits of the northern beaches, on Evans River, in the Fifield gold fields, and in the Parks district.

RUSSIA.

According to information received from the United States consul-general at Moscow, the output from several platinum districts in Russia in 1915 was 108,202.95 troy ounces, as officially reported, a decrease of 48,572 ounces from 1914. It is stated that the Nicholai-Pavdinsky Co. has completed a platinum refinery at Ekaterinburg, which will be under government control.

Platinum is produced in greatest abundance in the South Verkhoturshi district, followed by the Perm district, the North Verkho-

[1] Eng. and Min. Jour., vol. 100, p. 976, Dec. 11, 1915; idem, p. 119, Jan. 8, 1916.

turshi district, and the Cherdinak district. Mr. Snodgrass reports that platinum placers have been discovered 38 miles from Glagow (Viatka), in the Nicholai-Padvinsk district near the Bagron estate, and that an investigation of platinum placers has disclosed large reserves. Several new companies have been formed for the exploration and exploitation of platinum deposits, notably the Platinum Co., the Aktai Platinum Co., the Sozva-Ural Co., the Vogran Corporation, and the Nishni-Taghil Platinum & Mining Co.

Platinum produced in Russia, 1900–1915, in fine ounces.

Year.	Official.	Estimated total.	Year.	Official.	Estimated total.
1900	163,060	212,500	1908	156,792	250,000
1901	203,057	315,200	1909	164,118	264,000
1902	197,024	300,000	1910	175,716	275,000
1903	192,976	226,000	1911	180,400	300,000
1904	161,950	290,120	1912	177,375	300,000
1905	167,950	200,450	1913	173,642	250,000
1906	185,792	210,318	1914	156,775	241,200
1907	172,752	310,000	1915	108,203	124,000

SPAIN.

Under date of November 4, 1915, United States Consul Honey, at Madrid,[1] reported that the occurrence of platinum in the Ronda Mountains of southern Spain had been confirmed by the discoverer, Prof. Orueta. The Ronda Mountains are a western continuation of the Sierra Nevada, which skirts the Mediterranean coast eastward from Gibraltar. The platinum locality indicated in the reports seems to be near the town of Ronda, 50 miles north-northeast of Gibraltar, 35 miles west-northwest of Malaga, and 60 miles southeast of Seville.

Concerning these mountains the Spanish correspondent of the London Mining Journal [2] has to say:

> As regards the locality, the Sierra Nevada on entering the province of Malaga changes its east-west trend to one northeast-southwest, forming an abrupt slope between Malaga and Gibraltar. The end of the chain is called the Sierra de Ronda and contains several ranges of igneous rocks of the peridotite family, the most extensive covering 72 kilometers by 20. There are nine smaller masses in the same district of lesser importance.
>
> The rock system has been the subject of careful observation and its analogy with that of the Urals noted, but it was left for Mr. Orueta, of the Mapa geológico, to note the absolute similarity of the two chains. The peridotites of the Sierra de Ronda vary according to the proportion of basic and acid elements which they contain. The central mass is formed by the most basic rock dunite, which was the main object of Mr. Orueta's study. This dunite consists of a combination of olivine and chromite, the platinum being always associated with the latter. The metal is not concentrated as in the alluvial, but scattered throughout the mass.

After the announcement of this discovery the Spanish Government took possession of the ground, has prohibited prospecting in the vicinity, and has arranged for financing the necessary drilling and testing to determine the extent and value of the deposit.[3]

T. C. Earl,[4] in discussing the discovery in the Ronda Mountains, states that he has noted platinum in the streams of several of the

[1] Commerce Reports, Dec. 11, 1915, p. 290.
[2] Vol. 112, p. 41, Jan. 15, 1916.
[3] Commerce Reports, Jan. 7, 1916.
[4] Platinum in Spain: Min. Jour. (London), vol. 3, p. 860, Dec. 11, 1915.

northern provinces of Spain south of the Cantabrian range, which borders on the Bay of Biscay. Most of the streams in this region mentioned by him appear to head in the Cantabrian range or in the westward continuation of the Pyrennees and in that range itself. Mr. Earl also calls attention to the fact that platinum is present in places in Granada, east of the Province of Malaga, the scene of the most recent discoveries.

TASMANIA.

There is little to say concerning the Tasmanian platinum mines in addition to the report in Mineral Resources for 1914. It is reported, however,[1] that Tasmanian osmiridium, which formerly went to Germany, is now being refined in the United States, and it is believed that most of the future output will be refined here.

USES OF PLATINUM.

The jewelry industry and dentistry apparently consume about equal quantities of platinum and represent the largest proportion of platinum used in the United States. There is a considerable consumption in the manufacture of chemical utensils, including anodes used in the production of caustic alkali, and of particular importance during the last two years is the consumption by makers of sulphuric acid.

The jewelry industry, always more or less influenced by the dictates of fashion, uses large quantities of platinum and probably has felt the present stringency more than the industries which put platinum to a real and necessary use. Platinum makes excellent settings for gems, but it is believed that this use is not essential and that, so far as public opinion can be influenced, pressure should be brought to bear to stop this waste of a metal that is essential in many industries. True, platinum in jewelry can be recovered, but once in private ownership it is practically lost to the industry. Platinum is more difficult to work than gold or some of the white alloys of gold and platinum or of platinum and palladium, which are also less expensive. It would seem that some of the more common metals, such as tungsten, molybdenum, or the chromium-cobalt alloy, stellite, might well be used for jewelry in place of platinum. These have a silvery-white color, not quite so white as platinum, and though they do not work as easily as the noble metal they have possibilities which should be appreciated.

The manufacturers of platinum for use in dentistry have realized the importance of finding substitutes for the expensive metal, and the results of an investigation conducted for the National Dental Association recently made public [2] may be summarized as follows:

The substitute for platinum must satisfy the following conditions: Its melting point must be at least well above 1,200° C.; it must not be affected by those chemical compounds formed in its application, nor should it oxidize at a soldering temperature; it must possess sufficient strength to resist stresses tending to change its form while in

[1] Commerce Reports, Suppl. 60, p. 8, July 12, 1915.

[2] Fahrenwald, F. A., A development of practical substitutes for platinum and its alloys, with special reference to alloys of tungsten and molybdenum: Am. Inst. Min. Eng. Bull. 109, pp. 103–149, January, 1916.

place and at the same time be sufficiently pliable to be worked to the desired shape; its coefficient of expansion must be low; it should readily unite with gold, silver, and other metals and their solders; its cost should be low as compared with platinum. Of binary alloys of chromium, manganese, iron, cobalt, copper, silver, gold, and palladium, only those of palladium with gold and silver have any practical value. Palladium-silver alloys can be made which will meet the requirements of dental foil and cost from 1 to 50 per cent less than platinum. Palladium-gold alloys are superior to the palladium-silver alloys but more expensive. No alloy of gold, silver, and palladium was found which would replace platinum-iridium alloys where hardness and strength are required.

Tests of tungsten and molybdenum, which can not be worked by ordinary fusion methods, were made. It was found that ordinary wires of these metals coated with gold and palladium met most of the conditions of hardness and strength, but were sometimes as brittle as glass. Methods of overcoming this brittleness and of producing uniform results are described. Brittleness is ascribed to coarseness of crystallization, which can be avoided by proper manipulation in preparing briquets and in drawing wire and can be controlled by metallographic studies of material in course of production. As a result of this investigation a substitute for platinum was practically produced, "in many ways superior to platinum and its alloys," by coating pure ductile tungsten with gold, palladium, or alloys of these metals.

In the electrical industry platinum has largely been replaced by tungsten, molybdenum, and nickel-chrome alloys. Various alloys have been perfected to meet different conditions under which platinum was formerly used. One of the latest, rights to which have been recently acquired by the General Electric Co.,[1] is a copper-jacketed nickel-steel wire having an outside coating of platinum. This wire is said to have a coefficient of expansion such that in sealing an incandescent lamp a tight joint is assured. Thomas A. Edison has been granted patents (U. S. patent No. 1163329) for producing films of tungsten for incandescent lamps. It is noted [2] that recently the Hoskin Manufacturing Co. was sustained in its contention that the General Electric Co.'s alloy calorite was an infringement of the Marsh patent (U. S. patent 811859) covering a nickel-chrome-alloy for electrical use.

Platinum dishes and utensils for chemical investigation have become essential in accurate analytical work. That chemical platinum ware of different makers differs in composition and life is evidenced by a recent study by the United States Bureau of Standards.[3] This article describes and discusses experiments for the thermoelectric, microscopic, and chemical tests for the determination of platinum purity and concludes:

> There has been devised a simple thermoelectric method suitable for the determination of the purity of platinum ware. This method does not mar the article tested and gives data for the classification of platinum in terms of its equivalent iridium or rhodium content * * *. A method has been developed for determination of the exact loss on treating of platinum crucibles by means of a suitable electric furnace

[1] Jour. Ind. and Eng. Chemistry, vol. 8, No. 1, p. 86, January, 1916.
[2] Metal. and Chem. Eng., vol. 13, pp. 414–15, July, 1915.
[3] Burgess, G. K., and Sale, P. D., A study of the quality of platinum ware: U. S. Bur. Standards Sci. Paper 254, 1915.

containing no heated metal parts. * * * The loss of weight due to heating per 100 centimeters of practically iron-free crucible surface at 1,200° C. ranged from 0.71 Mg. to 2.69 Mg. per hour, the lesser losses being for crucibles containing rhodium and the greater losses being associated with iridium. * * * Iron appears to lessen somewhat the loss of weight on heating, but its presence is objectionable on account of the soluble oxide formed on the crucible surface. * * * It appears to be possible, from a thermoelectric and microscopic examination of a crucible, to predict its probable loss of weight on heating within limits close enough for analytical purposes. * * * Suggestions are offered concerning the specifications of highest grade platinum crucibles, including the substitution of rhodium to 5 per cent for iridium, and the practical elimination of iron.

Much attention has been given to the perfection of substitutes for platinum for use in chemical work. Although several alloys are employed for certain purposes in which platinum was formerly used, it does not appear that any successful substitute has been found for platinum for the dishes and crucibles used in analytical work. These dishes must of necessity be such that they are not affected by the reagents used. Recent experiments conducted by Prof. Parr [1] have resulted in the development of an alloy which is resistant to nitric acid. The alloy was conceived on the idea of combining elements of positive and negative electric properties in such a manner that the alloy would have a zero electric potential. The analysis [2] of one of the alloys made during these experiments, which satisfied the conditions required, is given below.

Analysis of acid-resisting alloy.

[S. A. Braley and F. E. Rowland, analysts.]

Cu	6.42	Fe	0.76
Mn	.98	Cr	21.07
Si	1.04	Mo	4.67
W	2.13		
Ni	60.65		98.81
Al	1.09		

As stated in the report for 1914,[3] a considerable quantity of platinum is used by the makers of sulphuric acid in what is known as the contact process. How great a quantity is so utilized has probably not heretofore been generally realized. Through the courtesy of most of the makers of sulphuric acid by the contact process, an estimate can be given for the quantity of platinum used in the industry; but as a few of the operators have not supplied figures, the quantity stated approximately is known to be less than that actually used. From the best information available at present it would seem that approximately 43,888 ounces of platinum are contained in about 1,487,000 pounds of contact mass used in the various sulphuric-acid plants of the United States, which use the contact process. The losses reported by these companies range from a negligible minimum to a maximum of 0.25 grams per ton of acid. Under the best practice it is believed that there should be little or no loss of platinum, for even though the mass may become "sickened," because of impurities in the gases that enter the contact chamber, it is possible to rejuvenate the mass with almost no loss.

[1] Parr, S. W., The development of an acid-resisting alloy: Am. Inst. Metals. Advance copy 19, 1915.
[2] Idem., p. 6.
[3] Production of platinum and allied metals in 1914; U. S. Geol. Survey Mineral Resources, 1914, pt. 1. pp. 337-338, 1915.

A recent patent (U. S. patent 1,157,693, dated Oct. 13, 1915) to the Carborundum Co.[1] aims to perform the three stages in the contact process in one operation. The invention consists of an acid-proof pipe with permeable carborundum diaphram, upon which platinum is deposited in the ordinary way, which can be maintained at a constant temperature by electrical energy, and which not only acts as a catalyzer but also heats the gases to the temperature necessary for most effective yield of sulphuric acid.

MINING AND METALLURGY OF PLATINUM.

GENERAL CONDITIONS.

The saving of crude platinum in the ordinary operations of placer mining is not efficient. In fact, it would appear that platinum is saved in many operations more by accident than by design. The recovery of the individual metals of the platinum group, which are ordinarily found alloyed in varying proportions in nature, is a problem for the expert metallurgist or chemist, and can not be accomplished with any degree of satisfaction by persons unacquainted with the intricacies of the process.

The following notes are compiled from various sources in response to frequent demands upon the Survey for information on methods of mining platinum and treating the crude material. They are accompanied by citations to some of the more important articles published, and are offered to give the layman a starting point in his investigations.

Most of the refined platinum and allied metals produced in the United States is obtained in the electrolytic refining of gold bullion and blister copper. Crude platinum is obtained from the California and Oregon placer mines, and this also needs to be refined. In discussing the metallurgy of the platinum metals, therefore, we have to deal first with the mining of crude platinum, next the electrolytic refining of gold and copper, and finally the chemical methods for separating the metals of the platinum group from one another.

PLACER RECOVERY.[1]

The platinum recovered in placer work in the United States is of secondary importance. The gravel deposits are worked mainly for the gold they contain, and the saving devices used are designed chiefly with this in view. Mechanical improvements to overcome difficulties in saving fine gold and platinum are also in use at some of the mines.

In general, the crude platinum of the western placers is found in relatively small scales or flakes, some larger than one-eighth inch in diameter, but the majority less than one-sixteenth inch in size, many being under one thirty-sixth inch. These flakes, like flakes of gold, have a tendency to elude capture in the ordinary miner's sluice, and probably a large part of the flake gold and platinum has heretofore been carried in suspension to tailing piles. Undercurrents in the

[1] Metal. and Chem. Eng., vol. 13, pp. 971-972, Dec. 15, 1915.

[2] Mr. Charles Janin, of the Bureau of Mines, has kindly revised this section of the report. It is hoped that more detailed information concerning placer-mining methods may be given in a report on the placer deposits of the United States now in preparation as the joint work of the United States Geological Survey and the Bureau of Mines. This report will not only cover the geology of the placer deposits, but will contain a discussion of the technology of placer mining.

sluice lines seem to have made a greater saving of the fine gold than ordinary sluices, but they do not appear to have been entirely efficient as savers of gold and platinum. Burlap and canvas tables have also been used with more or less success. Many types of specially designed machines have been tried and discarded, though undoubtedly some have merit and a few are making a more or less satisfactory saving.

The loss of fine gold and platinum in ordinary hydraulic operations is due to several causes, among which may be mentioned running pulp too fast and agitating it too much to permit settling, failure to clean up often enough to prevent packing of riffles and consequent formation of smooth slopes, over which metals readily flow under pressure, and failure to provide settling boxes for fine material carried in suspension. The first two of these causes have been remedied to some extent along Snake River, in Idaho, by the introduction of the wide burlap tables whose construction and use have been outlined by the writer [1] as follows:

> A sluice of special type, known as the burlap table, used also on some of the dredges, has proved one of the best appliances for saving the fine gold. In working with burlap tables the main sluice leading from the working is set at any convenient grade. Near the lower end is a section with a perforated steel bottom, which allows the fine heavy sands and gold to drop through to sluices set at right angles to the line of the main sluice. The transverse sluices are in reality launders which deliver the sands to a series of burlap tables. Each burlap table is from 16 to 30 feet long and 3 or 4 feet wide. It is usually set at a grade of 1 inch to 12 inches, but the grade needs to be adjusted to meet different conditions. Most tables are built with two drops at least. The pulp from the launder sluices is fed to the burlap tables through adjustable openings, so that it flows over the table in a thin, even sheet. The heavy sands and gold are caught by the rough surface of the burlap, and the light sands run to waste. In some places the tailings are rerun. In operation the tables are cleaned as often as necessary by taking up the burlaps and washing them in tubs of clear water. These concentrates, together with those washed from the bottom of the tables, are either placed in a grinding pan or revolving barrel for treatment with quicksilver and weak cyanide solution or cleaned with a rocker. The latter method, while attaining somewhat better results than the simple rocking of the gravels, is not efficient. In some of the burlap tables the first section of the table—that nearest the launder sluice—has a silver-plated copper bottom coated with quicksilver for amalgamating the gold. The number of tables varies with different conditions. In some places all the tables are on one side of the main sluice. In fact, each operator has his particular design of table and method of handling the gravel.

This device is fairly efficient, but its capacity is not large owing to the frequent stops necessary for cleaning up, as the burlaps soon become choked with heavy sands and gold, and the burlap table does not provide for settling fine grains in suspension.

The burlap table is really one form of undercurrent, many types of which are in use in the western placers, and all of which work on the same principles, namely, the increase of settling by checking velocity. They also spread the pulp over wider surfaces and lessen the thickness of pulp. Various types of undercurrents are described by Haley,[2] whose article has been discussed by Ulrich,[3] Haffey,[4] and Haley [5] in subsequent issues of the Mining and Scientific Press. Most of these articles agree in the opinion that undercurrents are to a certain extent efficient, but that they do not save all the gold and platinum that might be saved with more complete installation. Haley points out in particular that the problem to be solved is really a question of

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[1] Hill, J. M., Notes on the fine gold of Snake River, Idaho: U. S. Geol. Survey Bull. 620, p. 284, 1915.
[2] Haley, C. S., Construction of undercurrents: Min. and Sci. Press, vol. 110, p. 679, May 1, 1915.
[3] Ulrich, B. T., Undercurrents: Min. and Sci. Press, vol. 110, pp. 866–867, June 5, 1915.
[4] Haffey, C. W., Construction of undercurrents: Min. and Sci. Press, vol. 110, p. 797, June 26, 1915.
[5] Haley, C. S., Undercurrents: Min. and Sci. Press, vol. 111, p. 6, July 3, 1915.

whether the additional equipment will pay rather than a question of whether it will save more gold. The question of more efficient placer methods has been carefully considered by Nicol,[1] who says that the losses in present practices are "much more serious than is usually admitted—especially in associated and included particles of precious metals existing in concentratable grains of heavy mineral." He brings out the fact that gold and platinum are in some deposits included in hematite and other heavy minerals, which in ordinary practice are allowed to go with the tailings. The losses he concludes are due largely to the fact that in present practice all the gold and platinum that is caught is saved in a one-stage process. The difficulties of this process he summarizes as follows:

> Any form of riffle that does not "boil" will pack and all material will pass over and no gold (or platinum) will be caught. Any form of riffle that "boils" effectively will keep itself clear and in an efficient state to catch gold, but at the expense of practically all of the "heavy concentrate," and of a certain amount of fine gold and of nearly all of the spongy or flaky gold (and platinum) whose settling factor approximates the heavy concentrate, and also of all the included gold in the heavy concentrate.

Nicol's suggestions for more effective placer metallurgy may be summarized: Use ordinary sluice box mainly for washing, disintegrating, transportation, and catching coarse gold.

Eliminate all over three-fourths inch size by screening.

Eliminate entirely fixed riffle undercurrents and avoid any attempt at one-stage separation of fine gold.

Dewater undersize in some form of spitzkasten.

Use some form of continuous discharge concentrating table to catch all heavy minerals from which free gold and platinum may be separated afterwards.

Screen a second time and sort undersize material, which then can be sent to crusher or waste as its value dictates.

Dewater all fines, concentrate on table or machine, and dry.

Use magnetic separator on dry fine concentrate.

Re-treat nonmagnetic residue on a concentrating table capable of making several products. Most of the gold and platinum should be in the first two products and may be saved by smelting, by amalgamation with sodium amalgam, or be sold direct to refiners.

Treat all products according to their value.

The process outlined by Nicol's suggestion seems to be more particularly suited to the saving of platinum from the concentrate of ordinary placer plants. The content of platinum in most of the placer deposits of the Western States does not apparently warrant a more elaborate plant than is commonly used. Day's experiments[2] showed the suitability of Wilfley and other shaking tables for the concentration of "black sands," and Nicol describes several special machines designed for concentration of heavy sand.

It is realized that a large number of the placer mines which contain platinum are neither so situated nor so extensive as to warrant the installation of such an elaborate process as that outlined above. It would seem that in such mines it might be advisable to save the heavier concentrate found in the riffles for subsequent treatment, either in custom plants suitably situated to care for the output of

[1] Nicol, J. M., The metallurgy of alluvial mining: Min. and Sci. Press, vol. 110, pp. 837–840, 869–872, May 20, 1915.

[2] Day, D. T., Black sands of the Pacific slope: U. S. Geol. Survey Mineral Resources, 1905, pp. 1175–1258, 1906.

a number of mines or by some simple, economical additional concentration process that could be developed at the mine.

As much of the crude platinum produced in the United States is recovered by dredges, it would be interesting to know what proportion of the platinum content of the gravels is actually saved on the dredges. So far as the writer is aware, no estimates of this saving are published. In fact, little is published and perhaps little is known of the actual recovery of gold and platinum by dredges. As pointed out by Janin[1] the estimation of dredge recovery is a difficult matter, because, in the first place, the actual mineral content of the gravel dredged is difficult to arrive at; and, in the second place, it is still more difficult to obtain satisfactory information concerning tailing losses. Of the average gold content indicated by prospecting, 75 to 80 per cent is usually considered recoverable by dredges, but the actual recovery of the content may be greater or less than these percentages.

It would seem that there is considerable loss of flour gold and platinum in dredge operations. Neill[2] has described an installation of jigs in the sluice line of a dredge on Merced River, which demonstrated their value in saving fine gold. That this idea has met with some consideration is shown by the fact that recently the *Natomas No. 7* dredge, near Folsom, has been equipped with Neill jigs of which Eddy[3] says: "The recovery by this process has already been proved to reduce the value of the tailings of No. 7 dredge to a negligible amount." The concentrates from these jigs are ground in a Hardinge mill, and the pulp is passed over a shaking amalgamator and finally over a silver-plated amalgam plate before being discharged. It is said that 97 per cent of the recovery from the tailings is made in the Hardinge mill and the shaking amalgamator.

Whether platinum is saved by this installation is not stated, but the probabilities seem to favor the use of some such treatment of fines on dredges which are known to be digging gravels containing gold and platinum.

ELECTROLYTIC REFINING OF GOLD AND COPPER BULLION.

There are in the eastern United States at least nine copper refineries that recover platinum and palladium from blister copper.

There are also in the United States a number of plants that treat chiefly platinum metals, recovering them both from crude platinum and from "sweeps" from dental works and manufacturing jewelers' establishments. Some of the more important buyers of crude platinum and sweeps are listed below.

American Platinum Works, Newark, N. J.
Baker & Co. (Inc.), Newark, N. J.
J. Bishop & Co., Malvern, Pa.
Commercial Research Co., Long Island City, N. Y.
Thomas J. Dee & Co., Chicago, Ill.
Elizabethtown Smelting Co., Newark, N. J.
Goldsmith Bros. Smelting & Refining Co., Chicago, Ill.
Pacific Platinum Works, Los Angeles, Cal.
Roessler & Hasslacher Chemical Co., Perth Amboy, N. J.
S. S. White Dental Manufacturing Co., Philadelphia, Pa.

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[1] Janin, Charles, Recovery of gold in dredging: Min. and Sci. Press, vol. 109, pp. 717–721, Nov. 7, 1914.
[2] Neill, J. W., Application of jigs to gold dredging: Min. and Sci. Press, vol. 109, pp. 839–842, Nov. 28, 1914.
[3] Eddy, L. H., Jigs on a California dredge: Eng. and Min. Jour., vol. 101, pp. 207–208, Jan. 29, 1916.

GOLD BULLION.

There are several patents covering the electrolytic refining of gold bullion, detailed descriptions of some of which will be found in the references listed. The process used by the United States Mint, described by Durham,[1] may be briefly summarized as follows: Anodes of gold bullion $3\frac{1}{4}$ by $8\frac{3}{4}$ by $\frac{1}{2}$ inch, which contain about 90 per cent gold and 7 per cent silver, are treated in porcelain cells in an acid electrolyte of gold trichloride. Cathodes of pure gold 4 inches wide and 0.012 inch thick and weighing 4.5 ounces when new receive the gold deposited. They are not removed from the tanks till the weight reaches about 160 ounces. The cathodes, with their deposited gold, are remelted, cast as anodes, and a second deposit of gold is made, raising the fineness at least to 0.9997. During this process silver chloride is formed, which drops to the bottom of the cells and is collected. From the silver chloride metallic silver is recovered by treatment with metallic zinc and sulphuric acid, and this is refined to pure silver by electric deposition on pure silver cathodes in an electrolyte of silver nitrate. Copper and the platinum metals are dissolved in the gold chloride electrolyte. In practice the platinum metals are usually precipitated by adding ammonium chloride to the electrolyte when it contains about 5 per cent platinum and 0.5 per cent palladium, because if the proportion of these metals becomes much greater there is a tendency for them to deposit with the gold at the cathode.[2]

In time the electrolyte becomes spent when, together with all wash waters, it is passed over scrap iron, which precipitates copper and any other metals that may be carried by it. This impure cement copper is cast into anodes 5 by 14 by $\frac{3}{8}$ inch, and the copper is deposited on copper-plated lead cathodes in an acid copper-sulphate electrolyte.

The gold and silver and the platinum metals are insoluble in the copper-sulphate electrolyte, and fall to the bottom of the lead-lined wooden cells and are saved for further treatment for the extraction of gold and platinum.

BLISTER COPPER.

The aim of copper refining is to produce a fine copper and the saving of gold, silver, platinum, and other metals is of secondary importance in the process, though these metals recovered in many plants are of large aggregate value. The processes known as the Elkington (multiple) and Hayden (series) systems are in use. They differ in manipulation, but depend on the same action. Anodes of blister copper are treated in an acid electrolyte of copper sulphate. Fine copper is deposited on pure copper cathodes. During the process nickel, cobalt, iron, manganese, zinc, lead, and tin go into solution in the electrolyte, though some nickel goes into the mud also if the copper contains much of that metal. Lead, tin, gold, platinum, silver, tellurium, selenium, and sulphur are precipitated as "anode mud" and saved for treatment.

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[1] Durham, E. C., Electrolytic refining at the United States Mint, San Francisco, Cal.: Am. Inst. Min. Eng. Trans., vol. 42, pp. 874–901, October, 1911.

[2] Rose, T. K., The precious metals comprising gold, silver, and platinum, p. 195, New York, Van Nostrand, 1909.

SEPARATION OF PLATINUM GROUP METALS.

It is not known what processes are used by the refiners of platinum in this country, as the methods employed are trade secrets and jealously guarded by each refiner. Crude platinum and the muds from the gold and copper refineries can be refined by the Wollaston[1] process, though they usually go through a preliminary refining to remove lead, copper, and other base impurities.

The material to be refined is treated several hours in aqua regia, which dissolves most of the metals of the platinum group. The resulting solution is evaporated nearly to dryness to remove excess acid, diluted with water, and siphoned from the insoluble residue. This solution is treated with ammonium chloride, which precipitates ammonium chloroplatinate, from which spongy platinum is obtained by heating. This spongy platinum, containing about 2 per cent of iridium, is broken, sieved, and the fines made into paste with water and then compressed. This cake is strongly heated and hammered while red hot to make what is known as "hard metal." Pure platinum can be obtained by repeated refining of hard metal, the same method being used and care being taken to have an excess of acid in the solution, as this tends to prevent the precipitation of iridium.

The liquor is not entirely free from platinum even after most of this metal has been extracted, and it contains the other metals of the platinum group. Iridium chloride is precipitated from this solution by evaporation to a density the exact degree of which depends on various conditions and can not be definitely stated.

Two other methods of treating crude platinum, one for the production of pure platinum and the other for extraction of the platinum-group metals, quoted by Schnabel,[2] are given in full, as published by him:

G. Matthey produces pure platinum from the commercial crude metal by melting it with six times its amount of lead, granulating this alloy, and treating it with dilute hydrochloric acid, which disolves iron, lead, palladium, and rhodium, while platinum remains behind with iridium and small quantities of lead, rhodium, and other platinoid metals. This residue is boiled with aqua regia, when platinum and lead dissolve, and iridium remains behind. The lead is precipitated by sulphuric acid. The liquid is filtered from lead sulphate, and treated with excess of ammonium chloride and common salt to precipitate platinum in the usual way. If rhodium is present in the solution, the precipitate is rose-color instead of pure yellow. It is ignited with bisulphate of potash, which forms rhodium-potassium sulphate, while the platinum separates as metal. The double salt is dissolved by boiling the whole with water.

Wyott has brought forward a process for extracting the platinoid metals from residues and mother liquors. Platinum, palladium, and rhodium are dissolved out of the ores by aqua regia. The first is precipitated by ammonium chloride. The liquid is filtered off, neutralized by soda, and palladium cyanide ($PdCy_2$) precipitated from it by mercuric cyanide. Rhodium remains in the solution. The residue after treatment with aqua regia is to be heated in a stream of air, whereby osmium is converted into tetroxide, which volatilizes, and rhodium oxide is deposited in the hotter parts of the exit tube. The residue, after this heating, is mixed with salt and heated in a stream of chlorine. Sodium-iridium chloride is formed, which is dissolved by boiling water.

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[1] Rose, T. K., The precious metals comprising gold, silver, and platinum, pp. 267-699, New York, Van Nostrand, 1909.

[2] Schnabel, Carl, Handbook of metallurgy, vol. 2, p. 623, New York, Macmillan & Co., 1898.

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BAUXITE AND ALUMINUM.

By W. C. Phalen.

BAUXITE.

PRODUCTION.[1]

The production of bauxite in the United States in 1915 was 297,041 long tons, valued at $1,514,834, an increase of 77,723 long tons, or 35 per cent, in quantity and of $445,640, or 42 per cent, in value as compared with 1914. The increase for 1915 is abnormal in the bauxite industry and is accounted for by the increased activity in the production of metallic aluminum. The great bulk of the bauxite from which aluminum is produced comes from Arkansas, which in recent years has produced about 80 per cent of all the bauxite mined in the United States and in 1915 produced more than 90 per cent.

Other States which produced bauxite in 1915 were Alabama, Georgia, and Tennessee. The output in Alabama and Georgia was larger than in 1914, but that in Tennessee declined.

The average price of bauxite per long ton at the mines was $4.81 in 1912, $4.75 in 1913, $4.87 in 1914, and $5.10 in 1915.

Bauxite produced in the United States, 1889–1915, in long tons.

Year.	Georgia.	Alabama.	Arkansas.	Tennessee.	Total.	
					Quantity.	Value.
1889	728				728	$2,366
1890	1,844				1,844	6,012
1891	3,301	292			3,593	11,675
1892	5,110	5,408			10,518	34,183
1893	2,415	6,764			9,179	29,507
1894	2,050	9,016			11,066	35,818
1895	3,756	13,313			17,069	44,000
1896	7,313	11,051			18,364	47,338
1897	7,507	13,083			20,590	57,652
1898					25,149	75,437
1899	15,736	14,499	5,045		35,280	125,598
1900	19,739		3,445		23,184	89,676
1901	18,038		867		18,905	79,914
1902	22,677		4,645		27,322	120,366
1903	22,374		25,713		48,087	171,306
1904	21,913		25,748		47,661	235,704
1905	15,173		32,956		48,129	240,292
1906	25,065		50,267		75,332	368,311
1907	34,271		63,505		97,776	480,330
1908	14,464		37,703		52,167	263,968
1909	22,227		106,874		129,101	679,447
1910	33,096		115,836		148,932	716,258
1911	30,170		125,448		155,618	750,649
1912	19,587	14,173	126,105		159,865	768,932
1913	27,409		182,832		210,241	997,698
1914	18,547		200,771		219,318	1,069,194
1915	25,008		272,033		297,041	1,514,834

[1] The statistical tables of bauxite, aluminum, and aluminum salts in this report were prepared by Miss B. H. Stoddard, statistical clerk.

CONSUMPTION.

Bauxite produced, imported, and consumed in the United States, 1910–1915.

Year.	Production.		Imports.		Consumption.	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
1910	148,932	$716,258	15,669	$65,743	164,601	$782,001
1911	155,618	750,649	43,222	164,301	198,840	914,950
1912	159,865	768,932	26,214	95,431	186,079	864,363
1913	210,241	997,698	21,456	85,746	231,697	1,083,444
1914	219,318	1,069,194	24,844	96,500	244,162	1,165,694
1915	297,041	1,514,834	3,420	17,107	300,461	1,531,941

WORLD'S PRODUCTION.

World's production of bauxite, 1911–1914.

Country.	1911		1912		1913		1914	
	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.	Quantity (long tons).	Value.
United States	155,618	$750,649	159,865	$768,932	210,241	$997,698	219,318	$1,069,194
France	250,818	508,788	254,851	507,649	304,407	(a)	(a)	(a)
United Kingdom	6,007	6,297	5,790	6,881	6,055	7,606	8,286	10,507
Italy	5,600	12,300	6,596	20,618	6,843	16,101	3,844	9,046
India	12	24	950	2,511	[b] 1,184	161	[b] 514	156
	418,055	1,278,058	428,052	1,306,591	528,730	.....	.....	.....

[a] Statistics not available. [b] Used only in manufacture of cement.

BAUXITE INDUSTRY BY STATES.

ALABAMA.

The Republic Mining & Manufacturing Co. mined bauxite in the Rock Run district, Cherokee County, Ala., in 1915. This was the only company that operated in Alabama during the year.

ARKANSAS.

In Arkansas bauxite was produced in Pulaski County by the National Bauxite Co. and the Republic Mining & Manufacturing Co. The main work of the National Bauxite Co. is now done in the vicinity of Little Rock. In Saline County the American Bauxite Co. and the Globe Bauxite Co. were active.

GEORGIA.

Northwestern Georgia.—The Republic Mining & Manufacturing Co. operated in the Hermitage district, Floyd County. This company also worked under lease the property of the Cherokee Mining Co. near Linwood.

Central Georgia.—The National Bauxite Co. had a small force of men at work in the vicinity of Toomsboro, Wilkinson County. The mine worked is at the eastern edge of the town. The ore occurs as

a blanket deposit and in places is as much as 15 feet thick; it is capped by soil grading into ferruginous clay, and is underlain by stiff white clay.

About a mile north of Toomsboro is another property belonging to the National Bauxite Co. and known as the Carswell mine, and form it about 75 carloads of bauxite have been taken. The mine is now idle. The ore at this place is considered to be of washing quality.

Near Wriley station the Republic Mining & Manufacturing Co. operated during the first half of 1915 on the Parker and Daniel properties. Toward the end of the year work was drawing to a close on the property of Col. George Carswell. The ore at the large opening on the Parker and Daniel properties varies from 3½ to 5 feet in thickness, with an overburden of about 8 feet. There is a small rotary drier at this mine, in which wood is used for fuel. The dried ore is hauled to Wriley station, 1½ miles away.

There is a great deal of low-grade bauxite in the region of Gordon, McIntyre, Toomsboro, and Irwinton, in Wilkinson County. All these localities are on or near the Central of Georgia Railway, approximately 30 miles east of Macon. This low-grade material can probably not be marketed under present conditions, but without doubt the time will come when such material will have value.

About 60 miles southeast of Macon, in Sumter County, there is an important bauxite deposit at the Sweetwater mine, which belongs to the Republic Mining & Manufacturing Co. The mine is about 5 miles east of Andersonville, on Sweetwater Creek, a branch of Flint River. The bauxite occurs here as a true bedded deposit, conformable with both the overlying and the underlying beds. The bed that is worked is 5 to 6 feet thick, with an overburden of 35 to 40 feet, and lies on a stratum of white clay. A section of the overburden shows 20 feet of sand, 2 feet of purple-mottled clay, and 18 to 20 feet of white clay.

The bauxite obtained at the Sweetwater mine is of excellent grade, containing 58 to 60 per cent of alumina and less than 2 per cent of iron oxide. Most of it goes into the manufacture of aluminum salts, but some has been used in making aluminum. The proportion of overburden removed to that of ore mined is large. Operations began at the Sweetwater mine in May, 1914. The ore, after drying, is hauled to Republic spur, about 3½ miles away.

There are other bauxite prospects in this vicinity, which should be of interest to those in search of aluminum ore. Some of them are about 3 miles east of Andersonville, on Sweetwater Creek; 2 to 3 miles north of Andersonville, on Boggy Branch; and near Oglethorpe, Macon County. The National Bauxite Co. owns prospects in the Boggy Branch district.

It is reported that the Columbia Kaolin & Aluminum Co., of Washington, D. C., will develop deposits of clay and bauxite in Wilkinson County in the vicinity of Gordon, McIntyre, and Irwinton. A narrow-gage railroad will be built, connecting the deposits with Gordon, 3 miles away. Plants will be built for drying the bauxite, for preparing the clay for market, and for making alum.

A new occurrence of bauxite.—A new occurrence of bauxite has been reported by the Georgia Geological Survey. The new locality is at the base of Pine Mountain, Meriwether County, about 3 miles west

of Warm Springs. The length of the outcropping deposit is approximately 200 feet. Analyses of the samples show 51 to 54 per cent of alumina, with iron oxide and silica.

H. K. Shearer, of the Georgia Geological Survey, states that the bauxite appears to be associated with local beds of clay of Cretaceous age, and is therefore of the same age as the bauxite found in the vicinity of Andersonville, Sumter County. If this interpretation is true, it is of considerable scientific interest, as pointing to the extension of the Cretaceous sea much farther northwest than has been supposed heretofore, and as indicating that this sea covered much of the present Piedmont area of Georgia. The presence of warm springs in the vicinity is regarded as significant and as indicating one means whereby the bauxite deposits may have originated.

TENNESSEE.

Bauxite was mined at Sherman Heights, near Chattanooga, on the southeastern slope of Missionary Ridge, in 1915. The work was done by the National Bauxite Co. The old Perry mine, long operated by the company, has cost so much in recent years from clay slides that the company has decided to abandon it permanently. It was expected that the last ore would be removed from it by the end of 1915. Early in November, 1915, when this locality was visited by the writer, some prospecting was in progress on the side of the ridge above the main opening, and it was the intention of the company to work out any ore found there in quantity. Some bauxite came from the Gibson mine, near Keenburg, Carter County, in the eastern part of the State.

BAUXITE IN BRITISH AND DUTCH GUIANA, SOUTH AMERICA.[1]

During the last two years there has been considerable activity in exploring for bauxite in British and Dutch Guiana. These efforts have resulted in locating bodies of this mineral in both colonies, and the prospects for those engaged in the industry are believed to be very satisfactory.

A syndicate or working agreement has been formed among the interested parties and from 13,000 to 14,000 acres of land has been purchased, mineral rights to over 6,000 acres have been secured, and application has been made to the Government of British Guiana for the lease of three tracts of Crown land of 500 acres each. All these tracts are on or near Demerara River, in the vicinity of Wismar, Christinburg, and Three Friends, from 65 to 80 miles above Georgetown. Other deposits are known to the local government, and application has been made for particulars as to their location.

Active operations have been begun in Dutch Guiana, but owing to the fact that the leases for Crown lands required in British Guiana have been held up by the British Government, to which they were referred for approval, no active development has yet been undertaken in this colony.

The extent of the deposits of bauxite in Dutch Guiana is not known, but it is believed to be fully as great as in British Guiana. Some of the known deposits are at Oncribo, Para Creek, Surinam

[1] From a memorandum of United States consul George E. Chamberlin, Georgetown, British Guiana, dated May 31, 1916.

River, about 10 kilometers from Onverwacht station; at Rena Reu Creek, Portorico, on Surinam River; on Cotteca River; and on Marechals Branch of Surinam River.

The laws of British and Dutch Guiana do not prevent American citizens from acquiring right for prospecting and mining minerals, but in British Guiana only British subjects can acquire rights to explore for mineral oil.

Applications for copies of the regulations relating to concessions or leases of Crown lands in British Guiana should be made to the State Department, Washington, D. C.

USES OF BAUXITE.

The chief uses of bauxite are as follows: (1) As raw material in the production of metallic aluminum; (2) in the manufacture of aluminum salts; (3) in the manufacture of bauxite bricks; (4) in the manufacture of alundum (fused alumina) for use as an abrasive. The use of bauxite in the manufacture of calcium aluminate to give a quick set to plaster compositions should be added, as well as the extended use which alundum is finding in the refractory industries.

1. The use of bauxite in the production of metallic aluminum is by far the most important of those enumerated. A large part of the output of Arkansas is so used, and the figures of production from this State have shown remarkable growth during recent years. A large part of the imported French bauxite has also been used in the manufacture of metallic aluminum.

2. Only the purer bauxite is used in the manufacture of chemicals, such as alum, aluminum sulphate, and aluminum salts in general. For this use freedom from oxide of iron is essential.

3. Bauxite is used in the manufacture of bauxite bricks for furnace linings. The purer the bauxite used, the more refractory is the resulting brick; moreover, the addition of bauxite to refractory clays not only increases their content of alumina but also their refractoriness. The method of making bauxite brick, a representative anaylsis of them, and the troubles sometimes encountered in their use were set forth in Mineral Resources for 1913.

Kenneth Seaver [1] has discussed the use of alumina in making bauxite brick. The two kinds of brick in common use, made of hydrous oxide of aluminum, contain 56 and 77 per cent alumina, percentages which represent the extreme proportions of alumina of value in this industry. The characteristics of these two kinds of brick are quite different. The brick containing 56 per cent alumina is used as a fire-clay brick, but it will withstand higher heat. The brick containing 77 per cent alumina has been used as a substitute for magnesia brick, commonly called magnesite brick, for open-hearth and similar work. It has given excellent results. Under normal conditions it probably can not be produced as cheaply as magnesite brick.

An instance is cited where bauxite brick were used in the port end of the furnace, forming a bulkhead for that particular open-hearth furnace for 365 heats, at the end of which time a new roof was installed. The opposite port, in which magnesia brick were used, was found in worse condition. There seem to be great possibilities connected with the use of alumina brick.

[1] Am. Inst. Min. Eng., December, 1915, pp. 2505-2506.

4. Bauxite is used on a large scale at Niagara Falls in the manufacture of the artificial abrasive alundum. This abrasive is made in the electric furnace by fusing calcined bauxite. It is high in crystalline aluminum oxide and virtually amounts to a form of artificial corundum. The quality of the product is under complete control and can be duplicated with ease for use in the various abrasive processes, a factor of great importance in any successful abrasive industry. Alundum is particularly efficient in the grinding of steel.

5. The application of bauxite in the manufacture of calcium aluminate to give a quick set to plasters is discussed in Mineral Resources for 1911.[1]

OTHER SOURCES OF ALUMINA.

ALUNITE.

In connection with the preparation of potassium sulphate from alunite at Marysvale, Utah, a by-product is obtained consisting largely of alumina. A small quantity of this alumina was shipped from Marysvale during 1915. The potash industry at Marysvale did not attain very large proportions in 1915, but later on this condition may change. Production of two such valuable products as potassium sulphate and alumina ought to tend greatly to stabilize the industry should sharp competition be encountered in the sale of potash salts at the close of the present war in Europe. There are no known bauxite deposits west of Arkansas, and a cheap source of high-grade alumina is of the first importance in any attempt to start aluminum works on the Pacific coast. The possibilities in the situation appear to be great, especially in connection with the future development of water power in the West.

F. K. Cameron has devised a process for the treatment of alunite and has applied for a patent. Essentially the process consists in roasting the alunite at a comparatively low temperature, at which there is a very small loss of oxides of sulphur. The roasted alunite is then leached (preferably with counter current system) and yields a crude alumina containing silica and ferruginous material, and a solution of alum, with usually an excess of alumina as sulphate. Roasting at a low temperature avoids "fixing" the potash or rendering that constituent less easily extracted. The mixture of alum and alumina sulphate recovered from the solution is then roasted at a temperature just high enough to expel the oxides of sulphur, the gas mixture being mainly sulphur trioxide. The roasted mix is then lixiviated, yielding a solution of pure potassium sulphate and a residue of very pure alumina. The gas mixture is conducted through a suspension of the finely divided residue obtained in leaching the roasted alunite. A solution of salts of alumina is formed which can readily be filtered from the residue of silica and other valueless components. The solution, when evaporated, yields a product mainly of aluminum sulphate, valuable itself as a precipitant and as a mordant; or it may be made a source of further pure alumina merely by roasting. This process involves recovering salts from two aqueous solutions instead of one. The entire process is intended to be continuous.

[1] Phalen, W. C., Bauxite and aluminum: U. S. Geol. Survey Mineral Resources, 1911, pt. 1, p. 931, 1912.

SILICATE ROCKS.

In the last few years many processes have been devised and patented whose object was the extraction of potash salts from the silicates of aluminum and potassium, such as feldspar, leucite-bearing rocks, and sericite. The conclusion seems to be that if any process of extracting potash salts is to be commercially successful, other products of value must also be obtained, one of which is alumina.

A. H. Rogers [1] has found that by grinding a mixture of leucite and limestone in proper proportions, as in cement manufacture, and heating it in a kiln, a clinker is produced which is similar to cement clinker. This is simply ground and washed, whereupon alkali and alumina in the form of an alkaline aluminate go into solution. The alumina may be separated as in bauxite refining. The resulting alumina is as good as that obtained from bauxite. This work has been going on for some time on a small experimental scale and, though a high extraction has not always been obtained, owing to the difficulty of controlling the temperature, it is considered that with the uniform conditions obtainable in a large furnace 75 to 80 per cent of both potash and alumina are recoverable.

PROCESSES FOR PRODUCING OR PURIFYING ALUMINA.

Several processes have been devised for the production or purification of alumina and have appeared in patent specifications during 1915. Some of these are outlined below.

G. Schwahn [2] has secured a patent on a process for obtaining alumina from the anhydrous sulphate of aluminum. The sulphate is subjected to heat and steam and the acid is driven off. The alumina produced is suitable for electrolytic reduction to metallic aluminum. In another patent [3] Schwahn proposes to form the aluminum sulphate by dissolving alumina out of earthy materials by means of sulphuric acid. The aluminum sulphate is converted to alumina. As the latter process makes the elimination of silica feasible, it makes available such compounds of alumina as kaolinite, pholerite, and ordinary clay. It is claimed that the cost per unit of weight of product of extracting alumina from clay is less by this process than the cost of extracting it from bauxite by any soda process.

Paul R. Hershman [4] has invented a process of treating calcined "alunite, alum rock, and alum stone" for the purpose of converting the alumina into a condition which renders it soluble in alkali. The process consists essentially of heating with carbon, coke, and coal. The product containing the alkali-soluble alumina and aluminum carbide is dissolved by heating with caustic soda. The alumina may then be recovered by the Bayer or other suitable processes.

In the preparation of alumina for reduction to the metal, great care has to be exercised in removing all the silica possible. One of the most common processes employed in the purification of bauxite is known as the Bayer process. H. Howard [5] has found that the so-called "red mud" resulting from the Bayer process has under

[1] Min. and Met. Soc. America Bull. 83, vol. 8, No. 4, pp. 93–95, Apr. 30, 1915.
[2] U. S. patent 1132735, dated Mar. 23, 1915.
[3] U. S. patent 1132737, dated Mar. 23, 1915.
[4] U. S. patent 1137617, dated Apr. 27, 1915.
[5] U. S. patent 1137860, dated May 4, 1915.

certain conditions the property of removing most of the silica from alkaline aluminate solutions. As a result of the treatment, aluminum hydrate, containing only 0.02 to 0.04 per cent of silica, is readily obtained.

A. Badin [1] has devised a process for fixing nitrogen, which is also a method for purifying bauxite. The bauxite, mixed with carbon, is caused to pass into a flame produced by the combustion of coal dust, whereby the nitrogen is fixed. Alumina may be obtained from the resulting nitride.

P. Bunet [2] has devised a process for fixing nitrogen in the form of aluminum nitride, from which alumina may be obtained.

H. T. Kalmus, W. L. Savell, and K. B. Blake [3] have secured letters patent on a method of obtaining metallic aluminum from silicates, of which syenite is taken as an example. The pulverized rock is digested with a solution of sulphur dioxide in water, whereby much of the alumina and more or less of the silica are dissolved. The digested mass is then relieved of part of the sulphur dioxide, and all or nearly all the silica precipitates. The silica is filtered off. More sulphur dioxide is driven off, and the alumina precipitates and is dried.

Max Buchner [4] has patented a process for producing alumina from clay. The clay, bauxite, and argillaceous shale are decomposed by acid, and the insoluble parts are filtered off. Ammonium hydrate is added, and the mixed precipitate is freed from iron by means of alkali lye, which dissolves the aluminum hydrate. The alumina is recovered by any of the well-known methods, preferably by self-precipitation.

ALUMINUM.

PRODUCTION AND CONSUMPTION.

The United States leads the nations in the production of metallic aluminum, and the marked increase in production in the United

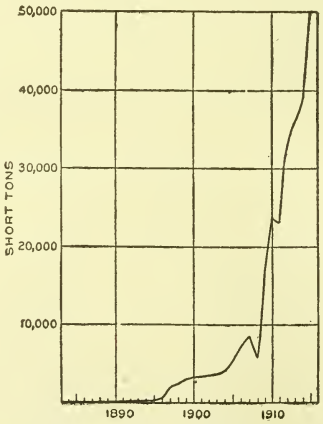

FIGURE 1.—Curve showing growth in the aluminum industry, 1885–1915.

States is well illustrated in the diagram (fig. 1), which is based on the figures given in the accompanying table. These figures give production to 1903 and consumption of the metal since that year.

[1] U. S. patent 1143482, dated June 15, 1915.
[2] U. S. patent 1145757, dated July 6, 1915.
[3] U. S. patent 1148092, dated July 27, 1915.
[4] U. S. patent 1162130, dated Nov. 30, 1915.

Aluminum produced or consumed in the United States, 1885–1915, in pounds.

1885	283	1896	1,300,000	1907	[1] 17,211,000
1886	3,000	1897	4,000,000	1908	[1] 11,152,000
1887	18,000	1898	5,200,000	1909	[1] 34,210,000
1888	19,000	1899	6,500,000	1910	[1] 47,734,000
1889	47,468	1900	7,150,000	1911	[1] 46,125,000
1890	61,281	1901	7,150,000	1912	[1] 65,607,000
1891	150,000	1902	7,300,000	1913	[1] 72,379,000
1892	259,885	1903	7,500,000	1914	[1] 79,129,000
1893	333,629	1904	[1] 8,600,000	1915	[1] 99,806,000
1894	550,000	1905	[1] 11,347,000		
1895	920,000	1906	[1] 14,910,000		556,672,546

The secondary aluminum produced in 1915 was 5,700 short tons; the recovered aluminum contained in alloys was 2,800 short tons.

EXPORTS.

Value of aluminum of domestic production exported, 1910–1915.

1910	$949,215	1912	$1,347,621	1914	$1,546,510
1911	1,158,603	1913	966,094	1915	3,682,117

THE DOMESTIC ALUMINUM INDUSTRY.

ALUMINUM CO. OF AMERICA.

In a recent speech in Detroit, Mr. A. V. Davis, president of the Aluminum Co. of America, stated that it is the desire and intention of the American producer to make enough metallic aluminum to supply the requirements of the United States, but that it is obviously difficult to maintain establishments large enough to supply domestic needs, while supplies from outside are cut off, and then during normal times, while imports are coming in, to store supplies or to close down plants altogether until another period comes on during which imports may again be cut off. There is only one cure for the present shortage in metallic aluminum, and that is to make more metal. This the American producer is preparing to do. A schedule has been planned that calls for the expenditure of $20,000,000 during 1915 and 1916. To carry out a plan of such magnitude takes time, and Mr. Davis reported that it would probably be May, 1916, before results could be obtained from the first of the company's work and probably be December, 1916, before the work was finished.

Toward the end of 1915 the Aluminum Co. of America was making nearly twice as much metal as in the same period in 1914, and when the new projects are in working order there will be so great an increase in production that the company will be able to supply the domestic demand even though no foreign metal is imported.

One of the most important developments of 1915 in the aluminum industry was the taking over of the property of the Southern Aluminum Co. by the Aluminum Co. of America. The Southern Aluminum Co., as reported in Mineral Resources for 1914, was forced to abandon work on its project at Whitney, N. C., on account of the war in Europe. The Aluminum Co. of America now (May, 1916) has

[1] Consumption. The figures for 1915 do not include the weights of imported leaf aluminum, valued at $1,294; table, kitchen, and hospital utensils, and other similar hollow ware, valued at $32,435; wire, valued at $39,021; and "All other manufactures" of aluminum, valued at $12,083.

a large force of men on the ground pushing operations forward as rapidly as possible. It is expected that a production will be made from this plant late in 1916 or early in 1917. The present power house at Whitney is to be dismantled and will be replaced by another of later type on the west side of the river. Further plans are reported for a steel-reinforced concrete building to cover a considerable acreage.

The large rolling and stamping mill which the company is erecting on Hudson River at Edgewater, N. J., will be not only the largest mill owned by the Aluminum Co. of America but the largest mill of its kind in the world.

It is reported that the erection of dams for the company's project on Little Tennessee River, near the border line between North Carolina and Tennessee, will be begun in 1916, and already preparations are being made for a cement plant at Chilhowee, 6 miles from Alcoa, the company's headquarters in this part of Tennessee. A statement as to the projected developments in this region was given in Mineral Resources for 1913. These developments will be pushed as fast as the market will take the product.

The water-power project on St. Lawrence River is also being developed.

NEW ALUMINUM PLANT.

It is reported that the Mineral Products Corporation is to build a plant in Utah for the production of metallic aluminum from alumina produced in making potassium sulphate from alunite. Some research work is reported as having been done on this alumina to produce a refractory material capable of withstanding high temperatures—for example, 2,500° C.

THE ALUMINUM MARKET.[1]

The aluminum market in 1915, like that for most of the metals, went through a series of very radical changes, as will be observed from the accompanying curve (fig. 2). According to Mr. Davis, president of the Aluminum Co. of America, this company, the only American producer, had been stocking the metal for a long period prior to the revival of business in April, 1915. At that time it had the largest stock of metal in the history of the company and perhaps the largest stock of aluminum that the world has ever known. The consumption of the metal then began to increase materially, and the war, cutting off imports to a large degree, also became a factor in the scarcity which ensued. The company has a Canadian plant from which a substantial quantity has come into this country during recent years, but in 1915, as well as in 1916, imports from this source have been stopped, owing to an embargo placed by the English War Office on the exportation of aluminum from Canada. The effect of this embargo, as well as the difficulty in getting other foreign aluminum, is plainly indicated in the statistics of imports into the United States during 1915. The price per pound ranged approximately from 19 cents at the beginning of the year to nearly 60 cents at the end.

[1] A very interesting discussion on what has been termed the primary and secondary market for aluminum is given in Metal Industry, January, 1916, p. 11, and February, 1916, p. 81.

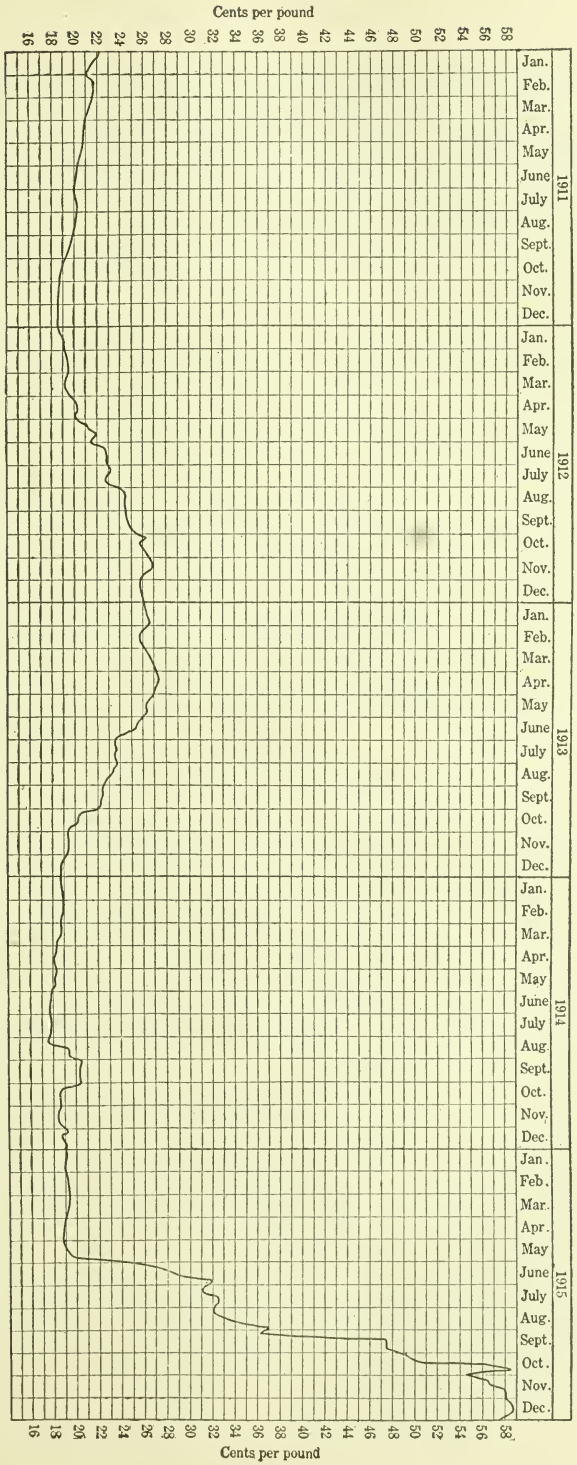
Cents per pound
16 18 20 22 24 26 28 30 32 34 36 38 40 42 44 46 48 50 52 54 56 58
Jan. Feb. Mar. Apr. May June July Aug. Sept. Oct. Nov. Dec.
1911
1912
1913
1914
1915
Cents per pound

FIGURE 2.—Curve showing prices at New York City by months, 1911–1915, of metallic aluminum in the form of No. 1 ingots. Based on weekly quotations given in the Engineering and Mining Journal.

USES OF ALUMINUM.

The rapid increase in consumption of metallic aluminum shows that the metal is gaining in favor on account of several of its inherent qualities, among which are lightness, comparative toughness, durability, and resistance to chemical corrosion. The fact that aluminum has been successfully soldered and welded enables it to take its place among the most useful of the metals. The outlook for metallic aluminum in the future is exceedingly bright.

Improvement in foundry methods for casting metallic aluminum, the result of long experience and of increased knowledge of suitable alloys, has made it possible for metallic aluminum to compete both with other sheet metals and with wood in the manufacture of automobile bodies. Large sections of aluminum castings are now in use in making touring cars and the inclosed bodies of certain other motor cars, which was not practicable 10 years ago. Cast aluminum is now also used for making automobile dashes. The advantages of aluminum construction are that bodies made of it are lighter than those made of other sheet metal and have a rigid surface which will not dent easily when handled. They are also safer in case of accident. The aluminum surface retains paint well, and the increased rigidity makes the car more durable.

The applications of metallic aluminum during the war in Europe have been many, and consequently the demand for it has been great. Duralumin, an alloy of aluminum containing 3 per cent of copper and 1 per cent of magnesium, has been extensively used in the manufacture of cartridges for rifles, shells, helmets, grenades, and, with soft iron, of shell fuses. In France its use in cartridges is said to have been abandoned, but there has been a great demand for it everywhere for camp equipment and in the construction of air craft of all kinds. In the United States its use in the manufacture of automobiles, air ships, and miscellaneous war supplies has been very great.

During the last few years steel-reinforced aluminum cables have come into use for overhead power lines. In the cable the aluminum wires are laid over a core of high-tensile steel, which bears the greater part of the strain when the cable is erected. The price of aluminum having become so high, it is reported that certain transmission lines in the United States have actually been replaced by copper wire with substantial financial gain. Reported thefts of aluminum wire attest the present value of the metal.

The uses of aluminum dust or powder have been mentioned in preceding reports. The powder is of value in metallurgy as a precipitant of the precious metals in the cyanide process. It is also used as a reducing agent, as in the Goldschmidt thermit process of welding. It is a constituent of bronze powder in the preparation of aluminum paint. One of the most interesting uses of aluminum dust at the present time is in the manufacture of explosives. Aluminum dust mixed with ammonium nitrate produces an explosive called "ammonal" that has given good results in mining and in shells. It has the advantage of being insensitive, is very stable, and is found to remain in good order for long periods. The reaction which takes place when ammonal explodes is probably represented by the equation

$$3NH_4NO_3 + 2Al = Al_2O_3 + 6H_2O + 3N_2$$

PROCESS OF PRODUCING METALLIC ALUMINUM.

Grenville Mellen [1] has patented a process for extracting aluminum from clay, kaolin, or aluminum silicates in general, which is as follows: The clay is fused with sodium sulphate in the presence of sulphuric acid, or with its equivalent of acid sodium sulphate, in such proportion as to form aluminum sulphate and free silica. The fusion product after cooling is dissolved in water, filtered, and treated with sodium fluoride. The aluminum fluoride which separates is fused with common salt and is electrolyzed.

ALLOYS.

A. Wilm [2] has found that a valuable improvement in aluminum alloys results from the combination of small quantities of manganese with aluminum, magnesium, and copper. The properties of the alloys with these four metals may be modified according to the proportions of manganese in combination. Different proportions of the metals which may be used are mentioned.

W. A. McAdams [3] has invented an aluminum alloy that is particularly adapted for casting. It consists of aluminum, 82 parts by weight; silver, 1 part; copper, 12 parts; and cadmium, 5 parts. In forming the alloy the aluminum is first melted, copper is then added, and the two metals are melted together. Then the silver is added and the temperature is lowered, but kept high enough to allow the cadmium to melt when it is introduced. The mixture is thoroughly stirred and then poured into molds to form the articles to be cast or ingots for shipment.

ALUMINUM SOLDER.

J. F. Gross [4] has invented a solder for use with aluminum or with aluminum and other metals. The composition of the solder is as follows: Block tin, 80 parts; lead, 16 parts; aluminum, 8 parts; zinc, 16 parts; and phosphorus tin, 8 parts. These elements are fused or melted together in the usual manner and molded into any desired shape.

J. Cayocca [5] has invented a solder designed for use with metallic aluminum without the use of an acid or flux. The solder is claimed to be noncorrosive and to have the appearance of the metal treated. It consists of tin, 12.8 ounces; lead, 3.2 ounces; and aluminum, 1 ounce. The ingredients are melted in the proportion stated and molded into bars of convenient size for handling.

E. Thaulow [6] has invented a compound to be used in welding aluminum and alloys containing aluminum. It has been found that a mixture of borax and sodium bisulphate is well adapted for this purpose, and the general claims made include these two chemical compounds.

F. Pucillo [7] has patented a process of treating aluminum to render it resistent to chemical attack, even at high temperatures. The treatment is applicable to castings, sheets, wire, tubes, or objects in gen-

[1] U. S. patent 1160431, dated Nov. 16, 1915.
[2] U. S. patent 1130785, dated Mar. 9, 1915.
[3] U. S. patent 1146185, dated July 13, 1915.
[4] U. S. patent 1145307, dated July 6, 1915.
[5] U. S. patent 1161612, dated Nov. 23, 1915.
[6] U. S. patent 1139923, dated May 18, 1915.
[7] U. S. patent 1130196, dated Mar. 2, 1915.

eral. It consists of treating the metal or object successively with alkaline solutions, acids, chlorides, and other salts, and mineral oils.

F. A. Roux [1] has patented a process for the treatment of surfaces of aluminum or of alloys of aluminum in order to prepare them to receive a metallic deposit. After the surface of the metal or alloy has been thoroughly cleansed, it is subjected to the action of diluted hydracids or alkalies to which has been added a salt of tin or other soluble metal. After rinsing, the surfaces are passed through a salt solution capable of fixing on them the tin or other metal and at the same time of expelling the hydrogen inclosed in the pulverulent metallic deposit formed on the aluminum. The aluminum salts and the alums in a saturated and somewhat warm solution are particularly suitable for this process, the more so as they have the advantageous property of dissolving the metallic oxides.

J. A. Hall [2] has invented an improved process of plating aluminum with such metals as copper, silver, and nickel. The surface of the aluminum is cleansed and the surface is plated with zinc by electrodeposition. This is effected very quickly. The surface is then plated with copper or silver. The second plating process consumes a few hours. The details and modifications required under peculiar conditions are described in the text of the patent.

A patent by Grenville Mellen [3] covers a process of melting aluminum or aluminum alloys. Another by J. W. Lawrie [4] involves a process of treating aluminum screenings, dross, slags, or analogous materials containing metallic aluminum.

H. W. Gillett,[5] of the Bureau of Mines, states that in melting aluminum chips the recoveries are usually comparatively low, owing to the quantities of dross that are formed. The reason for this is that the larger part of the aluminum chips are coated with a very thin film of aluminum oxide which prevents actual metallic contact and consequent welding together unless the superficial film is ruptured in some way or dissolved.

Two methods of melting aluminum chips, both of which are used on a large scale commercially, are described below. One of these processes is known as the "puddling" process; the other is based on the same principle as that of welding aluminum.

In the puddling process, according to Gillett,

> Melting is done in oil-fired furnaces, using iron pots, the furnaces being provided with close-fitting hoods. The empty pot is heated up to a low red, and a few shovels of chips put in. The furnace tender stands by with a big skimmer and works the chips over constantly till they start to get pasty. Before they are fully melted, he adds another small dose of chips and works that into the dough-like mass. The mass is not allowed to get visibly red. The addition and the working over of the chips is continued till the pot is full, holding the temperature practically at the melting point. By the constant stirring of the pasty mass, the tiny globules are pressed together, and the films of oxide and dross broken through, so that the result is a uniform pasty mass of metal, enveloping particles of dirt and oxide instead of a little molten metal below and a mass of dirt and oxide enveloping globules above. The pot is then covered and the metal heated to about 700° C. or 1,300° F., till the dirt and dross rise.
>
> Zinc chloride is then stirred into the risen dross, and the dross skimmed rapidly into water so as to stop oxidation and allow the recovery of entrained metal.
>
> This method gives about 70 per cent recovery on the ordinary dirty borings of commerce. On borings cut with a water-soluble cutting compound, if the wet bor-

[1] U. S. patent 1144000, dated June 22, 1915.
[2] U. S. patent 1147718, dated July 27, 1915.
[3] U. S. patent 1160430, dated Nov. 16, 1915.
[4] U. S. patent 1156606, dated Oct. 12, 1915.
[5] Metal Industry, October, 1915, pp. 417–418.

ings are allowed to dry out in the air, to oxidize and cake up, the recovery by this method is 50 to 60 per cent. But if these borings are very carefully kept free from dirt and are promptly dried, after cutting, by centrifuging, these clean, dry borings give 85 to 90 per cent recovery by this process. * * *

The other process is based on the same principle as that of welding aluminum, where fluxes composed of chlorides and fluorides of the alkalies or alkaline earths are used to dissolve the film of aluminum oxide and to allow the metal surfaces to unite, fluorides being the best known solvents for aluminum oxide as well as good ones for siliceous dirt. The chips are intimately mixed before charging with large amounts (20 to 50 per cent of the weight of the chips, depending on the degree of cleanliness of the chips) of a flux consisting of about 85 per cent common salt and 15 per cent powdered fluorspar. The mixture of chips and flux is put into large crucibles, heated in a coke fire. As soon as the chips start to melt, they are jammed down to make room for more mixture, and so on till the pot is full.

The pot is then left undisturbed without stirring till the flux is fully melted and fluid enough to absorb, either by true solution or by soaking up mechanically, the oxide and dirt, and to allow the tiny metallic globules to fall through it and collect in a molten mass. This requires at least 900° C. or 1,650° F.

On absolutely clean borings this method gives 90 to 95 per cent recovery, while chips very foul with dirt may give but 65 per cent.

PRODUCTION OF ALUMINUM SALTS.

Aluminum salts produced in and imported into the United States, 1911–1915.

Year.	Production.						Imports.[a]	
	Alum.			Aluminum sulphate.			Quantity (short tons).	Value.
	Quantity (short tons).	Value.	Price per ton.	Quantity (short tons).	Value.	Price per ton.		
1911	10,468	$329,686	$31.49	134,077	$2,743,336	$20.46	2,283	$56,833
1912	9,246	293,995	31.80	150,427	2,909,495	19.34	3,342	84,606
1913	9,605	312,822	32.57	157,749	2,977,708	18.88	2,702	66,549
1914	18,238	565,989	31.03	164,954	2,942,572	17.84	2,891	73,028
1915	24,915	699,256	28.07	169,153	3,224,495	19.06	1,408	34,320

[a] Includes alumina, aluminum hydrate, or refined bauxite, alum, alum cake, aluminum sulphate, aluminous cake, and alum in crystals or ground.

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GOLD, SILVER, AND COPPER IN ALASKA.

(MINES REPORT.)

By Alfred H. Brooks.

INTRODUCTION.[1]

The Alaska mining industry as a whole was more prosperous in 1915 than in any previous year, as is indicated by the value of the total mineral output. The highest value for any previous year was in 1906, but this was at a time when the bonanza placers of Fairbanks and Nome were yielding their greatest returns. Though the high value of the mineral production of 1915 was due for the most part to the output of copper, which was more than four times that of the preceding year, yet the mining of gold, silver, and other mineral products also increased as compared with 1914. The gold output of the placer mines was less than in 1914, but this was more than made up by the increased gold output of the lode mines.

The enormous expansion of the copper mining industry was due directly to the high price of copper, yet this expansion was made possible only because of the large developments that have been under way for several years. It augurs well for the future of the industry that the Alaska copper mines are now sufficiently developed to take advantage of highly favorable market conditions by producing so large an output.

There was also during 1915 marked advance in the auriferous lode mining industry in Alaska. This advance, as in previous years, was shown principally in southeastern Alaska and especially in the Juneau district, though progress was also made in some of the other fields. The inland gold lode camps are, however, still too isolated to permit of extensive lode development, which must await the completion of railroads.

Most of the important placer camps are also in the inland region, and these have not yet reacted to the stimulus of railroad construction. Some of the smaller placer camps made notable gains in output in 1915, as compared with 1914, but this gain was more than offset by

[1] Aid has been rendered in the preparation of this report by E. M. Aten, who has assisted in the collection of statistics from mines. The data on mining development here presented are all taken from U. S. Geol. Survey Bull. 642, which deals with the region in a more detailed way.

the lesser production from some of the more important Yukon districts. There are in the interior large areas of gold-bearing gravel whose values are too low to permit of profitable exploitation under the present high cost of operation. Until cheaper transportation and fuel lessen operating costs the placer output will continue to decline.

In this report, as in the reports for previous years, the attempt has been made to base statistics of output, as far as possible, on statements of individual producers, the only reliable source of information. Though the cordial cooperation of most of the important mine operators has been secured, there are still a few large producers of placer gold and many smaller ones who neglect to reply to the Survey request for information. For valuable information in connection with this work the writer is under special obligations to the Director of the United States Mint, to the collectors of the customs service, to the many United States commissioners in the Territory, to officials of banks and of transportation companies, and to prominent residents. All these data have been carefully sifted, and the accompanying figures are based upon them.

The limit of error of the statement of the total production of gold in the Territory is believed to be within 2 per cent. In the crediting of the proper amounts to individual districts, however, the error as to some districts may be as high as 8 per cent.

PRODUCTION.

Mine production of gold, silver, and copper in Alaska, 1914–15.

Year.	Gold.		Silver.		Copper.		Total. value.
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.	Quantity (pounds).	Value.	
1914	762,596	$15,764,259	394,805	$218,327	21,450,628	$2,852,934	$18,835,520
1915	807,966	16,702,144	1,071,782	543,393	86,509,312	15,139,129	32,384,666
Increase	45,370	937,885	676,977	325,066	65,058,684	12,286,195	13,549,146

The following table is an estimate of the total production of gold, silver, and copper in Alaska since the beginning of auriferous mining in 1880. For the early years the figures are probably far from being correct, but they are based on the best information now available.

Gold, silver, and copper produced in Alaska, 1880–1915.

Year.	Gold.		Silver.		Copper.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.	Quantity (pounds).	Value.
1880	967	$20,000			3,933	$826
1881	1,935	40,000				
1882	7,256	150,000				
1883	14,561	301,000				
1884	9,724	201,000	10,320	11,146		
1885	14,512	300,000				
1886	21,575	446,000				
1887	32,653	675,000				
1888	41,119	850,000	2,320	2,181		
1889	43,538	900,000	8,000	7,490		
1890	36,862	762,000	7,500	6,071		
1891	43,538	900,060	8,000	7,920		
1892	52,245	1,080,000	8,000	7,000		
1893	50,213	1,038,000	8,400	6,570		
1894	62,017	1,282,000	22,261	14,257		
1895	112,642	2,328,500	67,200	44,222		
1896	138,401	2,861,000	145,300	99,087		
1897	118,011	2,439,500	116,400	70,741		
1898	121,760	2,517,000	92,400	54,575		
1899	270,997	5,602,000	140,100	84,276		
1900	395,030	8,166,000	73,300	45,494		
1901	335,369	6,932,700	47,900	28,598	250,000	40,000
1902	400,709	8,283,400	92,000	48,590	360,000	41,400
1903	420,069	8,683,600	143,600	77,843	1,200,000	156,000
1904	443,115	9,160,000	198,700	114,934	2,043,586	275,676
1905	756,101	15,630,000	132,174	80,165	4,805,236	749,617
1906	1,066,030	22,036,794	203,500	136,345	5,871,811	1,133,260
1907	936,043	19,349,743	149,784	98,857	6,308,786	1,261,757
1908	933,290	19,292,818	135,672	71,906	4,585,362	605,267
1909	987,417	20,411,716	147,950	76,934	4,124,705	536,211
1910	780,131	16,126,749	157,850	85,239	4,241,689	538,695
1911	815,276	16,853,256	460,231	243,923	27,267,878	3,408,485
1912	829,435	17,145,951	515,186	316,839	29,230,491	4,823,031
1913	755,947	15,626,813	362,563	218,988	21,659,958	3,357,293
1914	762,596	15,764,259	394,805	218,327	21,450,628	2,852,934
1915	807,966	16,702,144	1,071,782	543,393	86,509,312	15,139,129
	12,619,050	260,858,943	4,923,198	2,821,911	219,913,375	34,919,581

The source of the production of Alaska gold by regions is shown in the following table. As already stated, there is probably far greater error in the estimate for the earlier years of production of gold by regions than in that of the total annual output.

Value of gold produced in Alaska, with approximate distribution, 1880–1915.

Year.	Pacific coast belt.	Copper River and Cook Inlet region.	Yukon basin.	Seward Peninsula and Northwest Alaska.	Total.
1880	$20,000				$20,000
1881	40,000				40,000
1882	150,000				150,000
1883	300,000		$1,000		301,000
1884	200,000		1,000		201,000
1885	275,000		25,000		300,000
1886	416,000		30,000		446,000
1887	645,000		30,000		675,000
1888	815,000		35,000		850,000
1889	860,000		40,000		900,000
1890	712,000		50,000		762,000
1891	800,000		100,000		900,000
1892	970,000		110,000		1,080,000
1893	838,000		200,000		1,038,000
1894	882,000		400,000		1,282,000
1895	1,569,500	$50,000	709,000		2,328,500
1896	1,941,000	120,000	800,000		2,861,000
1897	1,799,500	175,000	450,000	$15,000	2,439,500
1898	1,892,000	150,000	400,000	75,000	2,517,000
1899	2,152,000	150,000	500,000	2,800,000	5,602,000
1900	2,606,000	160,000	650,000	4,750,000	8,166,000
1901	2,072,000	180,000	550,000	4,130,700	6,932,700
1902	2,546,600	375,000	800,000	4,561,800	8,283,400
1903	2,843,000	375,000	1,000,000	4,465,600	8,683,600
1904	3,195,400	500,000	1,300,000	4,164,600	9,160,000
1905	3,430,000	500,000	6,900,000	4,800,000	15,630,000
1906	3,454,794	332,000	10,750,000	7,500,000	22,036,794
1907	2,891,743	275,000	9,183,000	7,000,000	19,349,743
1908	3,448,318	401,500	10,323,000	5,120,000	19,292,818
1909	4,264,716	265,000	[a] 11,580,000	4,302,000	20,411,716
1910	4,182,730	351,630	[a] 8,062,389	3,530,000	16,126,749
1911	4,265,573	313,538	[a] 9,139,145	3,135,000	16,853,256
1912	4,904,753	358,401	[a] 8,857,797	3,025,000	17,145,951
1913	4,529,529	378,643	[a] 8,183,641	2,535,000	15,626,813
1914	4,538,157	597,681	[a] 7,895,421	2,735,000	15,764,259
1915	5,808,978	605,390	[a] 7,367,776	2,920,000	16,702,144
Total	76,259,291	6,613,783	106,423,169	71,562,700	260,858,943

[a] Includes a small production from the Kuskokwim basin.

The subjoined table is an estimate, based on the best available data, of the source of the gold and silver produced in Alaska since mining began in 1880. Gold valued at about $65,100,000, or nearly a third of the total output, was produced prior to 1905, and there is but scant information about the source of it. Since that time fairly complete statistical returns are available, and it is believed that the figures presented in the following table are near enough the truth to have value. The figures presented in this table of the recovery of silver from placer gold and from siliceous ores are probably less accurate than those of the gold. Copper mining did not begin in Alaska until 1901, and the figures here presented for the gold and silver derived from copper ores should therefore be a close approximation to the actual output.

Gold and silver produced in Alaska, 1880–1915, by sources.

	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.
Siliceous ores	3,558,376	$73,558,164	986,188	$658,843
Copper ores	53,588	1,107,787	2,360,187	1,295,233
Placers	9,007,086	186,192,992	1,576,823	867,835
	12,619,050	260,858,943	4,923,198	2,821,911

This table shows that about 29 per cent of the total production of gold in Alaska has been obtained from the lode mines. In 1915 the lode production of gold was 38 per cent; in 1914, 32 per cent; in 1913, 31.6 per cent; and in 1912, 29 per cent of the total annual output of gold. These figures indicate a gradual transition from placer to lode mining. In the following table the production of precious metals in 1915 has been distributed as to sources.

Gold, silver, and copper produced in Alaska, 1915, by sources.

	Total quantity (short tons).	Gold.		Silver.		Copper.	
		Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.	Quantity (pounds).	Value.
Siliceous ores	3,020,607	293,588.99	$6,069,023	91,341	$46,310	.....	.....
Copper ores	369,600	7,407.23	153,121	897,839	455,204	86,509,312	$15,139,129
Placers	.....	506,970.00	10,480,000	82,602	41,879	.....	.....
	3,390,207	807,966 22.	16,702,144	1,071,782	543,393	86,509,312	15,139,129

There are no lead mines in Alaska, but considerable lead has been produced incidentally to the mining of lodes chiefly valuable for their gold content. The first production of lead was in 1892, since which time 1,261 tons of lead, valued at $109,604, have been produced from Alaska ores. In 1915 the Alaska mines produced 437 tons of lead, valued at $41,078, compared with a production in 1914 of 28 tons, valued at $1,344.[1]

Twenty-eight gold-lode mines, including several properties which made only small outputs, were operated the whole or a part of the year 1915 in Alaska, the same number as in 1914. Work was also done on many gold prospects, some of which produced a little gold. Of the producing mines 13 were in southeastern Alaska, 5 on Prince William Sound, 4 in Kenai Peninsula, 3 in the Willow Creek district, and 3 in the Fairbanks district. In 1914 the average value of the gold and silver content for all the ores mined was $2.79 a ton; the average for 1915 was $2.02.

Thirteen copper mines were operated in Alaska for the whole or a part of the year 1915, compared with 6 in 1913. Of these, 6 were in the Ketchikan district, 4 on Prince William Sound, and 3 in the Kotsina-Chitina district. The average copper content of the ore was

[1] Value calculated on the average price of lead, which was 4.7 cents a pound in 1915 and 3.9 cents in 1914.

11.7 per cent and the value of the gold and silver recovered about $1.65 to the ton. The average for 1914 was 6.98 per cent copper and $2.14 per ton for gold and silver content.

The value of the production of placer gold in 1915 was $10,480,000; that of 1914 was $10,730,000. As compared with 1914 there was a decrease in the output of placer gold from the Ruby, Hot Springs, Fairbanks, and Chisana districts and an increase from the Seward Peninsula, Koyukuk, Circle, and Nizina districts, as well as from some of the smaller camps. It is estimated that about 700 placer mines were operated in 1915, but many for only a part of the season; the number was 730 in 1914.

No new placer districts were discovered in 1915, though new ground was opened in regions previously known to be gold bearing. The most noteworthy of these was the Tolovana district, now on a productive basis. Some placers were also developed on Dime Creek, in the southeastern part of Seward Peninsula, and on Canyon Creek, in the lower Kuskokwim region.

The subjoined table shows approximately the total bulk of gravel mined annually in Alaska for several years and the value of the gold recovered per cubic yard. This table is based on certain assumptions which do not now admit of proof, but which are supported by a large number of facts. Therefore, although the table is only approximately correct, it indicates the magnitude of the true figures.

Gravel sluiced in Alaska placer mines and value of gold recovered per cubic yard, 1908–1915.

Years.	Quantity of gravel (cubic yards).	Value of gold recovered per cubic yard.	Years.	Quantity of gravel (cubic yards).	Value of gold recovered per cubic yard.
1908	4,275,000	$3.74	1912	7,050,000	$1.70
1909	4,418,000	3.66	1913	6,800,000	1.57
1910	4,036,000	2.97	1914	8,500,000	1.26
1911	5,790,000	2.17	1915	8,100,000	1.29

The increase in value of gold recovered per cubic yard from $1.26 in 1914 to $1.29 in 1915, as shown in this table, is a reflection of the fact that the dredging industry of the Seward Peninsula has declined somewhat. This increase, though very slight, is significant as being the first in eight years, as shown in the table, during the first seven of which the improved methods of mining had gradually reduced the average recovery per cubic yard. In other words, the larger plants have made it possible to mine placers of smaller value. It is not to be supposed, however, that the minimum average recovery has yet been reached, for the value of $1.29 a cubic yard is many times the average recovery of placer mining in the States.

Thirty-five gold dredges were operated in Alaska during 1915. Of these, 31 are located on Seward Peninsula, 2 in the Iditarod district, 1 in the Fairbanks, and 1 in the Birch Creek district. Two of the Seward Peninsula dredges were working on placers containing both gold and tin. In addition, there are two more dredges engaged in tin mining exclusively, which are not included in the statement. Therefore, there were 37 dredges in all employed in Alaska gold and tin mining during 1915.

It is estimated that these dredges handled 4,600,000 cubic yards of gravel and made a recovery of gold valued at $2,330,000. Forty-two gold dredges handled 4,450,000 cubic yards of gravel in Alaska in 1914 and recovered gold to the value of $2,350,000. The average gold recovery per cubic yard from dredges was, therefore, about 51 cents in 1915 and about 52 cents in 1914. The gold dredges of the Seward Peninsula made an average recovery of 35 cents a cubic yard in 1915 and 40 cents in 1914. Most of the dredges of the Yukon districts are working on placers of a relatively high gold tenor and their average recovery in 1915 was about 80 cents a yard.

The dredges of the Seward Peninsula that worked full time during 1915 were operated about 100 days in the more isolated camps; one near Nome was operated for 144 days. In the Alaska Yukon the dredging season, so far as determined by the few machines operated, is from 120 to 196 days. The large dredges of the Klondike, where climatic conditions are, if anything, less favorable than in the lower Yukon basin, are operated for at least 180 days and some have even worked for 270 days.

Some attempts at gold dredging were made in Alaska as early as 1900. This form of mining did not, however, reach a profitable stage until 1903, when two small dredges were successfully operated in Seward Peninsula. Dredging began in the Fortymile district in 1907 and in the Iditarod, Birch Creek, and Fairbanks districts in 1912. Up to the close of 1915 gold to the value of $12,430,894 has been mined by dredges. The distribution of this, by years, is shown in the following table:

Gold produced from dredge mining in Alaska, 1903–1915.

Year.	Number of dredges operated.	Value of gold.	Year.	Number of dredges operated.	Value of gold.
1903	2	$20,000	1910	18	$800,000
1904	3	25,000	1911	27	1,500,000
1905	3	40,000	1912	38	2,200,000
1906	3	120,000	1913	36	2,200,000
1907	4	250,000	1914	42	2,350,000
1908	4	170,901	1915	35	2,330,000
1909	14	424,993			12,430,894

REVIEW BY REGIONS.[1]

PACIFIC COAST BELT.

Southeastern Alaska.—Thirteen gold lode mines, including several which made only a small output, 6 copper mines, and 3 placer mines were operated in southeastern Alaska in 1915. The value of the mineral production from these mines is as follows: Gold, $5,435,586; copper (1,728,182 pounds), $302,431; silver, $50,137. A total of 2,989,730 tons of gold ore and 50,406 tons of copper ore were hoisted in 1915.

As in previous years, the largest mining developments were those of auriferous lodes near Juneau. Important advances were also made

[1] Only the larger features of the mining developments are here set forth. Those interested in mining developments of individual districts are referred to Bulletin 642, where they are presented in detail.

in copper mining in the Ketchikan district, which had the most prosperous year in its history. There was also a general revival of gold and copper mining throughout southeastern Alaska.

Beach mining.—Beach mining on a small scale continued in the Yakataga district and on Kodiak and Popof islands. There was also some hydraulic mining in Yakataga district.

PRINCE WILLIAM SOUND.

Four copper mines and five gold-lode mines were operated on Prince William Sound in 1915. The value of the total mineral production from this region, including gold, copper, and silver, was $1,340,996 in 1915, compared with $1,198,742 in 1914. Gold lode mining was confined to the Valdez and Port Wells districts, and the principal copper mines are located in the Ellamar district and on Latouche Island.

COPPER RIVER REGION.

Mining in the Copper River region includes the development of the copper mines in the Kotsina-Chitina copper belt and placer mining in Nizina, Bremner, and Chistochina districts. Three copper mines were operated throughout 1915, and about 18 placer mines were worked during the open season in this region. The productive copper mines are in the eastern part of the Kotsina-Chitina belt, and the most important placer mine operations are in the Nizina district. In the aggregate much development work was done on copper deposits not yet productive.

KENAI PENINSULA.

Twenty-five placer mines were operated in the Kenai Peninsula during 1915. Preparations for placer mining on a larger scale were also continued, but for the most part these developments did not reach a productive stage, though there was an actual increase in placer mining compared with previous years. Prospecting of dredging ground continued, but the dredge on Kenai River was not operated in 1915 and the one on Sixmile Creek for only a short time. Some production was made from four auriferous lodes, besides which there were some smaller outputs from other properties incidental to development work. The prospecting of auriferous lodes continued, though there were no notable developments of this form of mining.

SUSITNA-MATANUSKA REGION.

The productive mineral resources of the Susitna-Matanuska region are included in the Willow Creek gold-lode district and the Yentna and Valdez Creek placer districts. A little placer mining has also been done on Willow Creek and on tributaries of the upper Chickaloon. Three gold-lode mines and 25 placer mines were operated in this region during 1915, which produced gold to the value of $317,267. The three lode mines are in the Willow Creek district, where there is also 1 placer mine. About 20 placer mines were operated in the Yentna district and 5 in the Valdez Creek district.

YUKON BASIN.

General statement.—The value of the placer gold output of the Alaska Yukon districts in 1915 is estimated to have been $7,050,000, as compared with $7,570,000 in 1914. About 460 placer mines were operated in 1915. Only 3 lode mines were regularly productive in the Yukon basin in 1915, and these were all in the Fairbanks district, but several other lode properties produced some gold incidental to development. The important placer camps of the Yukon and an estimate of their output of gold in 1915 are shown in the following table:

Estimated value of gold produced from placers in the Yukon basin, by districts, 1915.

District.	Value.	District.	Value.
Fairbanks	$2,450,000	Circle	$230,000
Iditarod	2,050,000	All others	720,000
Ruby	700,000		
Hot Springs	610,000		7,050,000
Koyukuk	290,000		

The Yukon placer mines also produced silver valued at $31,118. These figures do not include the output of the lode mines, which are given below.

Fairbanks district.—The first placer mining in the Fairbanks district consisted of some small operations in 1903. Owing to the exhaustion of the bonanza deposits, the placer-gold output has been on the decline since 1908. In these 13 years gold to the value of about $65,490,000 has been won from the placers.

Lode mining began at Fairbanks in 1910, and since that time gold to the value of $1,068,845 has been produced by this industry. Therefore, the total gold production of Fairbanks district, including both lode and placer production, is $66,558,845. It is estimated that about 115 placer mines were operated in the district in 1915. Of the total value of the placer gold production about $500,000 was taken out during the winter. During 1915 three auriferous lode mines were operated on a regular productive basis in the Fairbanks district. These produced gold to the value of $217,776, which was taken from 6,545 tons of ore. There was also considerable development on other properties, incidental to which some gold ore was produced and was treated at small customs mills.

Ruby district.—Sixty-one placer mines were worked in the Ruby district during 1915, and the value of the gold production is estimated to have been $700,000. The most extensive mining was on Long and Poorman creeks and their tributaries. The most important event of the year was the preparation to install a dredge on Greenstone Creek, which will be in operation in 1916.

Hot Springs district.—About 30 placer mines, employing some 275 men, were operated in the Hot Springs district during the year. These yielded gold to the value of about $610,000, and incidentally some stream tin was won from the placers. The most important development was the opening up and mining of some placers on the lower part of Woodchopper Creek.

Iditarod district.—Twenty-four mines were operated in the Iditarod district in 1915, and gold to the value of $2,050,000 was produced. The largest operations were those of the two dredges, one on Flat Creek and one on Otter Creek. There were also some extensive operations by open-cut methods on Otter Creek, near Discovery, and large plants were operated near the heads of Flat, Chicken, and Happy creeks. The largest gold production was from Otter Creek and Flat Creek. A drag-line excavator, the first used in Alaska, was installed on Willow Creek during the summer and successfully operated.

There has been no lode mining in the Iditarod district, though some antimony-bearing quartz veins have been prospected. Some of these deposits carry cinnabar, which, with scheelite, is abundant in some of the concentrates from placer mining. The placer mining operations at the head of Flat Creek have revealed some quartz stringers, cutting the monsonite bedrock and carrying high gold values. Some of this material was dug out in 1914 and shipped and represents the first production of lode gold from the Iditarod district.

Smaller districts.—About 17 mines were operated in the Chisana district in the summer of 1915 and 2 in the previous winter. The total output of gold in the camp was $160,000, of which about $150,000 came from the placers of Bonanza Creek.

It is estimated that during 1915 about 30 placer mines were operated in the Fortymile and Eagle districts. Exact information in regard to the value of the gold produced is lacking, but it is probably about $90,000.

The Circle precinct includes the Birch Creek district, as well as the placers of Woodchopper and Beaver creeks. It is estimated that gold to the value of $230,000 was produced here from 50 mines. The principal event of the year was the installation of a new dredge on Mammoth Creek, which began to operate about June 1, 1915.

Mining continued in the Rampart district on about the same scale as in recent years. In the Rampart district proper about 15 mines were operated. Gold to the value of about $35,000 was recovered from these operations, which were all on a small scale.

In the Chandalar district there were no developments of importance. In the summer of 1915, 8 or 10 men worked on 5 claims and made a gold output of about $4,000 to $5,000. About 10 mines, employing perhaps 30 men, were operated in the Tenderfoot and Salchaket region. There was also a little mining on Kenyon Creek, in the Healy River district. Some smaller placer mining operations were also continued in the basin of Chena River, which was also the scene of considerable prospecting during the year. The operations named yielded gold to the value of $95,000.

Workable gold placer was discovered on Livengood Creek in Tolovana district, July 24, 1914. As a result there was a considerable influx of prospectors and miners into the new district during 1915. A deep channel was opened up on Livengood Creek and traced for several miles, and this has been the source of most of the gold produced. There has been, however, some open-cut mining on tributaries of Livengood and also on Olive Creek, which flows directly into the Tolovana River. Good prospects have also been found in the adjacent Hess Creek basin, but here there was no productive mining. It is probable that 40 or 50 claims were more or less systematically prospected in this district during 1915. Of these

probably 10 can be classed as productive mines, which produced gold to the value of about $80,000.

Mining continued in the Bonnifield and Kantishna districts on the same scale as in previous years, with a total gold production of about $40,000.

Thirty-five mines employing probably 150 men, were operated during 1915 in the Koyukuk district, including the Indian River region. The gold produced from these operations is estimated to have a value of $290,000. Of this amount about $225,000 was taken from the deep mines during the winter months. The deep mines of Hammond River made the largest production, but winter mining was also done in Nolan, Linda, and Gold creeks. The largest summer production was from the placers of Jay Creek, which were discovered in 1915.

It is estimated that 38 mines were operated in the Innoko district (including Cripple Mountain region) during 1915, and that they produced gold to the value of $190,000.

It is reported that in 1915 seven claims were developed in the Wade Hampton precinct, which lies in the lower Yukon basin, and that the total gold production had a value of about $25,000.

KUSKOKWIM REGION.

Mining continued in Takotna, Georgetown, Tuluksak-Aniak, and Goodnews Bay districts, of the Kuskokwim region. It is estimated that in all about 25 mines were operated and produced gold to the value of $100,000. Some valuable placer was found on Canyon Creek, in the southern part of the Tuluksak-Aniak district.

SEWARD PENINSULA.

The estimated value of the output of gold from Seward Peninsula in 1915 was $2,900,000; that of 1914 was $2,700,000. Including the gold dredges, it is estimated that 120 placer mines were operated on the peninsula in 1915. The distribution of the production of gold by districts is shown in the following table which, however, owing to the failure of some of the operators to make returns, is only an approximation.

Approximate distribution of gold produced in Seward Peninsula, by districts, 1915.

Nome district	$1,500,000
Council district	685,000
Fairhaven district	250,000
Solomon district	250,000
Kougarok district	140,000
Port Clarence and smaller districts	75,000
	2,900,000

Gold dredging continued on a large scale but was not as productive as in 1914. Thirty-one gold dredges were operated in Seward Peninsula in 1915, which, it is estimated, handled about 3,000,000 cubic yards of gravel yielding gold to the value of $1,050,000. Thirty-nine dredges were operated in 1914, which dug about 3,400,000 cubic yards of gravel and made a recovery of $1,280,000 in gold.

The total recovery of gold by dredges since this method of mining was first introduced in 1903 is estimated at $8,850,000. Of the 31 dredges operated in 1915 two were engaged in mining placers in the York district, which carry gold as well as tin. In addition to the gold dredges, two tin dredges were operated in the York district in 1915, making 33 dredges in all on the Seward Peninsula. Three gold dredges and one tin dredge were built in 1915.

There was more deep placer mining at Nome during 1915 than there has been for many years. About 36 deep placer mines were operated in the Nome district during the winter of 1914–15, and the value of their gold output, including those operated in summer, was about $300,000. Though there was a shortage of water in the peninsula during August, in general the season was favorable to placer mining operations. Some placers were developed during 1915 in the southeastern part of Seward Peninsula on Dime Creek, tributary to Koyuk River.

KOBUK REGION.

Placer mining in a small way continued in the Kobuk region during 1915. Four mines were worked in the Squirrel River district and in the Shungnak district. The entire gold output of the Kobuk region is estimated at $20,000.

LEAD.

By C. E. Siebenthal.

SUMMARY.

Summary of lead statistics, 1910–1915, in short tons.

	1910	1911	1912	1913	1914	1915
Total production of refined lead in the United States	470,272	486,979	480,894	462,460	542,122	550,055
Production of desilverized lead in the United States	328,954	331,032	339,646	330,593	383,903	388,594
Production of soft lead in the United States (including desilverized soft)	169,270	191,614	171,037	161,300	201,725	205,462
Production of antimonial lead in the United States	14,069	14,078	13,552	16,665	16,667	23,224
Production of lead from domestic ores	375,402	391,995	392,517	411,878	512,794	507,026
Production of secondary lead in the United States	55,422	54,284	67,168	72,834	61,062	78,900
Consumption of lead in the United States (disregarding stocks)	397,763	353,828	394,159	414,281	451,371	431,252

The output of refined lead in the United States from domestic ores in 1915 was 507,026 short tons, valued at $47,660,000, at the average price of refined lead in New York, as compared with 512,794 tons, valued at $39,998,000, at the average price in New York in 1914, a loss in quantity of 5,768 tons, about 1 per cent, and a gain in value of $7,662,000, nearly 20 per cent.

INTRODUCTION.

An estimate of the production of refined lead in 1915 was given out in the form of a press bulletin on January 3, 1916. This estimate was based on reports received from every smelter but two, giving the actual production for the first 10 or 11 months of 1915 and estimates for the remainder of the year. The complete figures for the production and consumption of primary [1] refined lead and for the imports and exports of lead in ore and bullion were given in an advance statement published May 10, 1916. The present report contains, in addition to the statistics given in that statement, tables and curves showing production, value, consumption, imports, exports, and prices for a period of years, and a summary of the metallurgical advance in 1915.

The statistics of production of lead in this country in 1915 have been compiled by the United States Geological Survey from confidential reports submitted by each lead-smelting company in operation during the year. The statistics of the recovery of secondary lead were also collected by the United States Geological Survey.

[1] "Primary lead," which is produced directly from ore, is here distinguished from "secondary lead," which is obtained by refining skimmings, drosses, and old metals. The statistics of secondary lead are given on p. 193. Wherever in this report the word "lead" is used without qualification it means primary lead.

The statistics of domestic consumption are taken in part from the smelter returns and in part from the records of the Bureau of Foreign and Domestic Commerce, of the Department of Commerce, and the statistics of foreign production and consumption are compiled from the sources indicated in connection with the tables here presented.

PRODUCTION.

PRODUCTION AND VALUE.

The refined lead produced in the United States since 1720 from domestic ores and from foreign ores and base bullion and its value at the average price in New York are shown in a table in the chapter on lead in Mineral Resources for 1914.

Production, price per pound, and value of refined lead in the United States, 1720–1915.

Year.	Desilverized lead.[a,b]	Soft lead.[c]	Total production.[b]	From domestic ores and base bullion.[b]	From foreign ores.	From foreign base bullion.	Price at New York.	Value.
	Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*		
1720–1905	5,251,079	2,081,836	7,332,915	6,032,383	1,300,532		.....	$634,403,000
1906	313,886	90,860	404,746	336,200	28,803	39,743	$0.057	46,141,000
1907	313,588	99,801	413,389	352,381	24,041	36,967	.053	43,819,000
1908	295,552	101,012	396,564	311,666	11,509	73,389	.042	33,311,000
1909	329,751	117,158	446,909	352,839	21,754	72,316	.043	38,434,000
1910	328,954	141,318	470,272	375,402	18,065	76,805	.044	41,384,000
1911	331,032	155,947	486,979	391,995	10,764	84,220	.045	43,828,000
1912	339,646	141,248	480,894	392,517	11,572	76,805	.045	43,280,000
1913	330,593	131,867	462,460	411,878	13,223	37,359	.044	40,696,000
1914	383,903	158,219	542,122	512,794	7,639	21,689	.039	42,286,000
1915	388,594	161,461	550,055	507,026	9,581	33,448	.047	51,705,000
	8,606,578	3,380,727	11,987,305	9,977,081	2,010,224		.....	1,059,287,000

[a] Desilverized soft lead is included; for quantity see page 191.
[b] Antimonial lead is excluded; for quantity see page 191.
[c] Desilverized soft lead is excluded.

PRODUCTION BY STATES.

The production of refined lead can with difficulty be apportioned according to sources of ore owing to the fact that lead refiners treat products already smelted whose origin may, as in custom refining, be unknown to them, as the identity of the ore and thus its original source is preserved only so far as the smelter. Accordingly, the following table is compiled, so far as possible, from smelter figures. It includes "pig lead" reported by all known smelters running on Mississippi Valley or southern lead ores and "work lead" produced at all other lead smelters in this country. The greater part of the product reported by smelters operated in conjunction with refineries is in terms of refined lead. A like part of the antimonial lead is thus eliminated from the "work lead" produced and appears only in the figures of production of antimonial lead.

In addition to the domestic lead ores smelted in this country, small quantities of domestic lead ore have been exported to smelters in Canada. In 1912 soft lead amounting to 63 tons was smelted from Wisconsin ores at Canadian smelters, and in 1913 soft lead amounting to 37 tons from Wisconsin ores and desilverized lead amounting to 98 tons from Idaho and Washington ores were smelted in Canadian smelters. In 1914 desilverized lead amounting to 31 tons and in 1915 desilverized lead amounting to 137 tons was smelted in Canada from Washington ores.

Primary lead smelted or refined in the United States, 1906–1915, by sources, in short tons.

Source of ore.	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Domestic ore:										
Alaska	8	.....	3	69	75	51	45	6	.....	358
Arizona	2,884	2,418	1,464	1,507	948	3,428	3,891	4,901	5,601	6,953
Arkansas [a]	.....	15	.....	14	.....	15	.....	.....	52	51
California	432	938	515	977	1,207	615	811	3,294	3,698	5,606
Colorado	50,497	52,552	28,729	30,865	38,542	30,442	37,039	42,840	41,198	32,352
Idaho	117,117	123,292	98,464	103,747	109,951	117,335	127,780	137,802	177,827	160,680
Illinois [a]	572	498	362	273	263	308	513	619	427	910
Iowa [a]	270	225	110	15	.....	.....	.....	.....	34	.....
Kansas [a]	1,932	1,798	2,293	2,763	1,308	2,522	1,937	1,504	1,043	1,320
Kentucky [a]	44	75	.....	.....	50	.....	91	16	16	95
Missouri [a]	111,075	122,856	122,451	141,105	161,659	182,203	162,610	152,430	194,275	195,634
Montana	2,485	2,145	2,320	1,451	1,943	2,484	2,517	3,256	4,386	4,853
Nevada	1,669	3,480	3,796	4,792	2,246	1,082	5,699	6,142	5,996	7,664
New Hampshire	.....	.....	.....	.....	.....	.....	.....	.....	.....	3
New Mexico	640	2,047	586	1,350	1,890	1,371	2,511	1,821	741	2,157
North Carolina	.....	.....	.....	.....	2	35	34	10	.....	.....
Oklahoma [a]	.....	404	1,409	2,268	1,805	1,925	2,500	3,214	3,916	4,346
Oregon	.....	5	7	7	.....	11	21	37	17	11
Pennsylvania	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
South Dakota	.....	.....	13	.....	8	33	12	7	2	5
Tennessee [a]	11	16	.....	.....	.....	.....	.....	.....	.....	8
Texas	25	12	42	44	36	57	30	108	89	111
Utah	56,260	55,540	42,455	66,648	60,605	54,933	60,664	71,069	88,976	106,105
Virginia	.....	83	13	.....	87	400	85	878	143	457
Washington	46	341	391	120	339	612	53	9	2	11
Wisconsin [a]	1,753	3,573	4,013	3,252	3,909	3,966	3,301	2,639	1,819	2,632
Wyoming	.....	.....	.....	.....	.....	.....	.....	.....	.....	6
Undistributed	380	896	36	317	101	48	120	63	99	116
Zinc residues	2,053	1,890	1,290	1,735	2,237	1,987	3,131	3,765	4,125	4,562
	350,153	375,099	310,762	363,319	389,211	405,863	415,395	436,430	534,482	537,012
Foreign ore:										
Africa	.....	288	.....	3,150	3,310	582	1,774	5,976	2,942	.....
Canada	7,238	2,607	162	66	25	122	29	16	2	1,174
Central America	112	23	12	20	3	28	.....	.....	.....	1
Mexico	21,435	20,204	10,145	16,944	11,704	7,333	7,407	4,512	2,386	5,437
South America	.....	919	1,186	1,536	2,996	2,677	2,332	2,617	1,821	2,829
Other foreign	18	.....	4	38	27	22	30	102	488	140
Foreign base bullion:										
Canada	.....	2,716	179	1,500	.....	.....	.....	.....	.....	.....
Mexico	39,743	34,251	73,210	70,816	76,805	84,220	76,805	37,359	21,689	33,173
South America	.....	.....	.....	.....	.....	.....	.....	.....	.....	275
	68,546	61,008	84,898	94,070	94,870	94,984	88,377	50,582	29,328	43,029
Grand total	418,699	436,107	395,660	457,389	484,081	500,847	503,772	487,012	563,810	580,041

[a] The lead produced by these States is nonargentiferous or soft lead.

SOFT LEAD.

The lead ores of the Mississippi Valley are almost free from silver, and the lead produced from them is known as "soft lead."

A little lead ore of this kind is also mined in Washington and other Western States, but in the last few years this ore has been smelted by plants treating argentiferous lead ore and thus the resulting lead has not been distinguished from the desilverized product of those plants. With two exceptions the smelters running exclusively on these soft-lead ores do not desilverize their product. Their output is shown in the column headed "Soft lead" in the table on page 188, giving the production of refined lead for 1720–1915. However, considerable soft-lead ore has been annually smelted and some purchased pig soft lead has been desilverized by the silver-lead smelters. Since 1904 the St. Louis Smelting & Refining Co. has regularly desilverized its product, and in 1913 the Picher Lead Co. and in 1915 the St. Joseph Lead Co. installed desilverizing kettles. This desilverized soft lead, for the years prior to 1906, has not been recorded separately from the lead produced from silver-lead ores, though the lead content of the soft-lead ores so smelted and desilverized has been recorded since 1894. Since 1906 the quantity of soft lead produced by each State has been recorded, as shown in the preceding table. In the table next following the output of the soft-lead smelters is given in the first column and the lead content of soft-lead ores smelted and desilverized is given in the second column. For the years 1904 and 1905 a part of the quantity given in the second column represents lead content of ore and a part refined lead. For the years 1906 to 1915 the quantity given represents refined lead alone.

In order to give a fair idea of the annual quantity of refined pig lead recovered from soft-lead ores for the period 1894–1905, the lead recovered from such ores by the silver-lead smelters has been estimated at the rate of recovery used in the official reports for these years. Even so, the figures do not give the total quantity of lead recovered from soft-lead ores, for the lead recovered in the form of pigments should be taken into account, as these pigments are made from soft-lead ores. On this combined basis of calculation the soft lead recovered in 1915 was about 42 per cent of the total domestic production of refined lead plus the domestic lead in pigments, as compared with 40 per cent in 1913 and 1914, with 44 per cent in 1912, and with about 50 per cent in 1911.

Soft lead produced in the United States, 1894–1915, in short tons.

Year.	Undesilverized.	Desilverized.		Total soft lead.
		Lead content of ore.	Recovered lead.	
1894	37,686	a 8,614	b 8,097	b 45,783
1895	39,890	a 13,706	b 12,884	b 52,774
1896	43,537	a 8,350	b 7,849	b 51,386
1897	43,553	a 12,989	b 12,210	b 55,763
1898	42,779	a 11,688	b 10,987	b 53,766
1899	40,566	a 13,878	b 13,045	b 53,611
1900	48,021	a 11,500	b 10,810	b 58,831
1901	57,898	a 9,274	b 8,718	b 66,616
1902	74,050	a 5,395	b 5,071	b 79,121
1903	83,444	a 3,153	b 2,961	b 86,408
1904	89,169	c 5,320	b 5,165	b 94,334
1905	85,455	c 18,603	b 18,556	b 104,011
1906	90,860	.....	25,000	115,860
1907	99,801	.....	29,829	129,630
1908	101,012	.....	29,869	130,881
1909	117,158	.....	32,532	149,690
1910	141,318	.....	27,952	169,270
1911	155,947	.....	35,667	191,614
1912	141,248	.....	29,789	171,037
1913	131,867	.....	29,433	161,300
1914	158,219	.....	43,506	201,725
1915	161,461	.....	44,001	205,462

a Lead content of ores smelted and desilverized.
b Estimated recovery of lead from lead content of ore.
c In part lead content of ores, in part refined lead.

ANTIMONIAL LEAD.

The production of antimonial lead from argentiferous lead ores derived from all sources, as reported by all lead refineries operating in this country, is shown for the period 1871–1906 (earlier years being estimated from the output of desilverized lead) in a table in the chapter on lead in Mineral Resources, 1914, to which the reader is referred.

Antimonial lead produced in the United States, 1907–1915, in short tons.

Year.	From domestic ore.	From foreign ore.	Total.	Value.	Antimony content.		Lead content, by difference.
					Quantity.	Percentage.	
1907	.....	.....	9,910	$1,322,985	1,561	15.8	8,349
1908	.....	.....	13,629	1,264,771	2,440	17.9	11,189
1909	8,889	4,007	12,896	1,231,019	2,360	18.3	10,536
1910	10,140	3,929	14,069	1,338,090	2,229	15.8	11,840
1911	9,636	4,442	14,078	1,380,556	2,254	16.0	11,824
1912	8,549	5,003	13,552	1,311,348	1,949	14.4	11,603
1913	14,667	1,998	16,665	1,591,854	2,508	15.0	14,157
1914	15,475	1,192	16,667	1,572,167	2,693	16.2	13,974
1915	19,371	3,853	23,224	3,665,736	3,425	14.8	19,799
Average composition, by percentage	.....	.....	.....	.....	.....	15.9	84.1

For further details of the production and consumption of antimony in the United States the reader is referred to the chapter on antimony in Mineral Resources, 1915.

LEAD PIGMENTS.

PIGMENTS SMELTED DIRECTLY FROM ORE.

In addition to the leaded zinc oxide and zinc-lead oxide, which are noted more particularly in connection with the production of zinc pigments, two other lead pigments are made directly from ore, namely, sublimed white lead and sublimed blue lead. Sublimed white lead consists of lead sulphate 75 per cent, lead oxide 20 per cent, and zinc oxide 5 per cent. Sublimed blue lead consists of lead sulphate 50 to 53 per cent, lead oxide 41 to 38 per cent, with small proportions of lead sulphide, lead sulphite, and zinc oxide. Zinc-lead oxide contains from 46 to 50 per cent of lead sulphate, from 52 to 46 per cent of zinc oxide, and a small quantity of zinc sulphate. No zinc-lead oxide is made at present. Leaded zinc oxide may vary from 4 to 20 per cent in lead sulphate, the remainder being zinc oxide, with a small portion of zinc sulphate.

In order not to disclose individual returns, the statistics of production of leaded zinc oxide and of sublimed lead (basic sulphate white and blue lead) have to be combined with those of zinc oxide. The marketed production of these pigments in 1915 was 141,383 short tons, valued at $14,962,461, as compared with the production in 1914 of 106,791 short tons, valued at $9,978,710. The output of sublimed lead increased slightly and that of leaded zinc oxide more than 65 per cent.

Lead content of pigments smelted from ore in the United States, 1907–1915, in short tons.

1907	7,099	1912	10,323
1908	8,278	1913	10,998
1909	7,292	1914	11,914
1910	7,603	1915	12,782
1911	7,678		

PIGMENTS CHEMICALLY MANUFACTURED FROM PIG LEAD.

Under this head are included basic carbonate of lead or corroded white lead, litharge, red lead, and orange mineral.

Chemically manufactured lead pigments marketed in 1914–1915.

Pigment.	1914			1915		
	Quantity (short tons).	Value.	Average price per ton.	Quantity (short tons).	Value.	Average price per ton.
Basic carbonate white lead:						
In oil	130,398	$16,983,587	$130.24	122,194	$15,879,835	$129.96
Dry	29,076	2,959,652	101.79	33,907	3,513,856	103.63
Red lead	19,123	2,221,073	116.15	19,435	2,397,900	123.38
Orange mineral						
Litharge	27,345	2,856,092	104.45	26,118	2,822,415	108.06
	205,942	25,020,404	.....	201,654	24,614,006	.....

SECONDARY LEAD.

Important sources of secondary lead are skimmings, drosses, old metal, and alloys, as babbitt, solder, and type metal. The recovery of lead by refining these materials constitutes an integral part of the lead industry. This business is mostly carried on at small refineries scattered over the United States, but the large smelters and refineries working primary lead frequently find it advantageous to incorporate material from secondary sources. The product of such secondary refineries is of two classes—pig lead and lead in alloys. In the latter case the lead may have been recovered in the form of pig lead and alloyed at the refinery, or it may have been refined as an alloy, being brought to the desired composition by addition of the requisite metal.

Secondary lead produced in the United States, 1909–1915, in short tons.

	Pig lead.	Lead in alloys.	Total recovered lead.	Value.
1909	18,360	23,327	41,687	$3,585,082
1910	29,492	25,930	55,422	4,877,136
1911	27,389	26,895	54,284	4,885,560
1912	30,266	36,902	67,168	6,045,120
1913	33,104	39,730	72,834	6,409,000
1914	29,337	31,725	61,062	4,763,000
1915	36,400	42,500	78,900	7,416,000

METALLURGY.

CONCENTRATION AND SEPARATION.

The problems of concentration and separation of lead ores do not differ essentially from those concerning zinc ores or the complex sulphide ores of lead and zinc. The various adaptations of the principles of flotation and of electrostatic separation to such ores have been discussed in the chapters on zinc in Mineral Resources of the United States for 1908 and for 1910–1915, to which the reader is referred.

The last two years have witnessed the extensive application of flotation to the concentration of lead ores in the United States. All the principal concentrating mills in the disseminated lead district of southeastern Missouri, with an aggregate capacity of daily treatment of 17,500 tons of crude ore averaging 3.6 per cent lead, have flotation units to handle the slimes and fines. Flotation will also be installed in the Federal Lead Co.'s 2,500-ton mill now building.

Ore flotation is extensively employed in treating the lead and lead-zinc ores of the Coeur d'Alene district in Idaho. J. M. Callow has stated that a certain flotation process is used at the Gold Hunter, Morning, Hercules, Bunker Hill & Sullivan, Caledonia, Last Chance, Hecla, and Standard mines; that it employs 50 flotation cells and treats daily from 1,500 to 2,000 tons of fines and slimes. Other processes are in operation at the Interstate-Callahan, Greenhill-Cleveland, and other mills in the district.

Ore flotation is employed in the treatment of lead and zinc ores at many places in Colorado and at some places in other Western States. A fair estimate of the additional recovery of lead in 1915, due to the flotation process, is 50,000 tons of metal.

SMELTING.

SMELTERS.

For a list of lead smelters and refineries in North America see the chapter on lead in Mineral Resources of the United States for 1914.

SMELTER CHANGES.

The Northport Smelting & Refining Co., composed of persons interested in the Hercules, the Tamarack, and other mining companies of the Coeur d'Alene region of Idaho, has purchased the old copper smelter at Northport, Wash., remodeled it thoroughly, and given it an equipment of labor-saving devices. Two 250-ton lead furnaces, 42 by 192 inches in size, with an 18-foot smelting column, were added and blown in early in March, 1916, and the construction of a third lead furnace was begun. Three of the six copper furnaces of the old plant were renovated and will eventually be operated. Four Dwight & Lloyd sintering machines will roast the concentrates received at the smelter. Furnace and roaster gases will be treated by the Cottrell fume precipitation process. The lead bullion produced will be treated at the affiliated refinery of the Pennsylvania Smelting Co., at Carnegie, near Pittsburgh, Pa.

The Bunker Hill & Sullivan Mining & Concentrating Co. decided in 1915 to build a complete lead smelter and refinery. Kellogg, Idaho, was finally selected as the place and construction has begun on a site a mile west of the Bunker Hill mine. The roasting department will consist of a 26-foot Wedge roaster and four 42-inch Dwight & Lloyd sintering machines. There will be three lead furnaces 48 by 180 inches in size, each having a 20-foot 6-inch smelting column. The capacity of each will be 300 tons a day. The bullion will be drawn hot from the blast furnaces by an electric crane to the refinery, which will use the Parkes process of zinc desilverization and will be equipped with two softening furnaces, four desilverizing kettles, two refining furnaces, four merchant kettles, a hard lead furnace, and a drossing furnace. The silver refinery will have four Faber du Faur retorts, two coupling furnaces, a fine-silver furnace, and a crucible furnace for gold smelting. Doré bars will be parted by the sulphuric acid process, the silver precipitated by copper, and the resulting copper sulphate crystallized and sold. The gases from the blast furnaces, roasters, and refinery furnaces will be passed through a bag house, and the filtered gases will escape from a 12-foot concrete stack 200 feet in height.

Improvements giving increased capacity were made in the lead departments of the El Paso and East Helena plants of the American Smelting & Refining Co.

The Picher Lead Co. was consolidated with the Eagle White Lead Co., under the corporate name The Eagle-Picher Lead Co., which will operate the Picher plant at Joplin, the new plant at Galena, Kans., and the Webb City Smelting & Manufacturing Co.'s plant at Webb City, Mo., as well as the zinc smelter at Collinsville, Ill., and the zinc smelter now building at Henryetta, Okla. Other establish-

ments of the company are the white lead corroding works at Cincinnati, Ohio, and the lead-oxide plant under construction at Newark, N. J. The Joplin plant has been greatly enlarged since 1913 by the addition of new lead furnaces, a desilverizing department, and other extensive improvements.

The St. Joseph Lead Co.'s smelter at Herculaneum, Mo., has also been remodeled and practically rebuilt in the last few years, among the additions being a bag house, several Dwight & Lloyd sinterers, and a desilverizing department.

TRADE CONDITIONS.

WORLD'S PRODUCTION.

Owing to the disturbed conditions in Europe no figures of the world's production since 1913 are available. For a table of the world's production of lead in that and prior years see the chapter on lead in Mineral Resources of the United States, 1913.

THE LEAD INDUSTRY AS AFFECTED BY THE WAR IN EUROPE.

The following tables of exports of lead and lead manufactures, repeating in part tables given elsewhere in this report and including figures later than the year to which this report pertains, are segregated here to show the effect of the war on the lead industry. Perhaps the most striking fact was the exportation of large quantities of domestic pig lead, something which had not occurred for many years and never before in such quantity.

Lead exported from the United States by six-month periods, 1914–1916, by classes.

	1914				1915				1916	
	January–June.		July–December.		January–June.		July–December.		January–June.	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
FROM DOMESTIC ORE.										
Lead, pigs or bars	40,323,662	$1,511,800	77,120,238	$2,989,874	115,903,983	$4,936,730	58,280,194	$2,860,268	93,233,404	$6,198,514
Lead manufactures	.....	633,234	.....	385,000	.....	732,875	.....	1,538,022	.....	1,080,821
FROM FOREIGN ORE.										
Lead ore, content	6,724,525	245,205	.....	.....	.....	.....	.....	.....	.....	.....
Bullion, content	10,944,350	378,286	.....	.....	.....	.....	.....	.....	.....	.....
Lead, pigs and bars	.....	.....	25,421,500	913,306	34,435,599	1,041,541	42,455,113	1,690,151	9,487,481	419,065
Lead manufactures	.....	1,810	.....	432	.....	31	.....	40,081	.....	516
Lead used in articles exported with benefit of drawback	7,595,127	[a] 301,500	11,416,486	[a] 431,500	6,040,015	[a] 262,700	1,926,287	[a] 90,535	9,489,870	[a] 645,311
	.....	3,071,835	.....	4,720,112	.....	6,973,877	.....	6,219,057	.....	8,344,227

[a] Represents the value of the metal used in making the articles exported with benefit of drawback.

Pig lead exported from the United States, by six-month periods and destination, 1914–1916, in short tons.

Destination.	January–June, 1914.		July–December, 1914.		January–June, 1915.		July–December, 1915.		January–June, 1916.	
	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Foreign.
Canada	.....	28	4,082	.....	6,176	58	13,913	4,217	12,634	607
Great Britain	7,153	3,963	16,995	6,270	25,945	10,480	5,247	9,551	5,356	1,905
Netherlands	4,720	1,592	2,019	28	677	739	268	1,768	1,527	305
Belgium	2,101	746	560	.....	.....	.....	.....	.....	.....	.....
France	.....	.....	.....	560	8,585	1,171	687	1,344	337	.....
Italy	.....	71	589	.....	1,560	2,030	449	561	336	.....
Germany	5,141	1,681	2,241	.....	.....	.....	.....	.....	.....	.....
Russia	448	.....	6,263	5,717	7,623	1,741	5,901	2,128	5,648	56
Japan	.....	.....	2,247	.....	2,081	.....	1,339	560	12,106	645
Other countries	599	753	3,564	136	5,305	999	1,336	1,098	8,673	1,226
	20,162	8,834	38,560	12,711	57,952	17,218	29,140	21,227	46,617	4,744

Lead exported from the United States, by months, 1914–1916, in short tons.

Month.	Lead, pigs and bars.		
	Domestic.	Foreign.	Foreign lead used in articles exported with benefit of drawback.
1914.			
January	.....	1,363	
February	.....	166	
March	5,838	246	3,798
April	5,931	3,663	
May	2,045	2,420	
June	6,348	976	
July	10,894	1,119	
August	5,486	.....	
September	2,793	923	5,640
October	7,829	2,521	
November	8,417	5,297	
December	3,141	2,851	
	58,722	21,545	9,438
1915.			
January	6,460	3,072	
February	3,820	1,778	
March	7,023	2,301	3,020
April	19,936	5,133	
May	15,312	3,021	
June	5,401	1,913	
July	1,452	3,224	
August	979	5,227	
September	2,458	3,723	963
October	5,787	3,284	
November	9,886	315	
December	8,578	5,454	
	87,092	38,445	3,983
1916.			
January	7,192	1,236	
February	10,246	1,229	
March	8,585	734	4,745
April	5,869	582	
May	7,558	641	
June	7,167	322	
	46,617	4,744	4,745

IMPORTS AND EXPORTS.

WAREHOUSE TRANSACTIONS.

Lead imported into the United States as metal or in ore may be entered for immediate consumption, in which case the duty is paid and the lead goes direct to the consumer; or it may be entered for warehouse, bond being given for double the amount of the estimated duty. In the accompanying tables the phrase "general imports" indicates the total imports, including both lead entered for immediate consumption and lead entered for warehouse. From warehouse the lead may be withdrawn for consumption by payment of duty, or it may remain in bond for smelting and refining, finally being either withdrawn for consumption or exported from warehouse with cancellation of bond. The lead entered for immediate consumption and that withdrawn from warehouse for consumption make up the "imports for consumption," which are expressed in the same terms as those in which they were imported. The lead imported for consumption may be actually used in this country, or it may be manufactured into articles which are exported, in which case the manufacturer is entitled to the benefit

of a drawback of 99 per cent of the duties paid. In the table below, showing foreign lead exported in manufactures with benefit of drawback, the lead is shown in the form in which it was originally imported. On account of diversity of form it is not feasible to show the articles exported with benefit of drawback. The foreign lead given in the table below as exported from warehouse is likewise shown in the form in which it was imported and entered for warehouse. Foreign lead exported from warehouse has, since July 1, 1915, been included by the Bureau of Foreign and Domestic Commerce in the domestic exports as "from foreign ore."

The items, foreign lead exported from warehouse, domestic exports of lead "from foreign ore," and foreign lead exported in manufactures with benefit of drawback, make up the total foreign lead going out of the country. Lead in warehouse and deductions by liquidation being disregarded, the difference between the sum of these exports of foreign lead and the total imports of lead constitutes the foreign lead consumed in this country. For the sake of simplicity this foreign lead is carried on the bonded customs warehouse records in the form in which the lead was entered until the bond is canceled. It must be clearly understood, therefore, that in the table of foreign exports of lead, on a later page, the lead there listed was not exported as lead content of ore and base bullion but as refined lead smelted and refined from them. There is no record kept of the lead in the form in which it is actually exported except for a portion of the articles manufactured from foreign lead and exported with benefit of drawback. For articles not made wholly of lead it would be useless to give weights. But each shipment on which drawback is claimed is accompanied by a manifest of the imported lead used in making the articles and the duty paid thereon. From these manifests is derived the statement of the total quantity of foreign lead used in manufactures exported with the benefit of drawback. For this reason the lead is given in the form in which it was imported.

The following table is taken from the reports of the Bureau of Foreign and Domestic Commerce. For the reasons given above, the lead is shown in the terms in which imported. For instance, a considerable part of the lead stated as remaining in ore and base bullion doubtless represents refined lead waiting at the bonded refinery for a favorable market for shipment. If this is borne in mind, the table gives a fair idea of the fluctuations of foreign stock at different times and in different localities.

Lead remaining in warehouse in the United States, 1910–1915, in pounds.

Dec. 31—	Form in which entered for warehouse.		Remaining at—					
			New York.		Chicago, Ill.	El Paso, Tex.	St. Louis, Mo.[a]	San Francisco, Cal.
	Lead in ore and base bullion.	Pigs, bars, and old.	Newark, N. J.	Perth Amboy, N. J.				
1910	71,794,443	149,082	7,548,936	36,112,136	21,090,631	6,937,667	.....	.....
1911	8,869,713	93,082	2,777,692	2,308,322	954,884	2,555,733	273,082	.....
1912	20,891,182	93,802	1,880,828	17,666,768	484,671	767,533	91,382	.....
1913	10,620,953	.....	8,785,551		80,880	1,683,091	71,431	.....
1914	15,333,064	3,837	10,309,592		94,775	4,802,961	125,736	.....
1915	24,338,933	.....	8,401,728		165,257	14,678,809	104,922	988,217

[a] Kansas City before 1914.

IMPORTS.

The following tables are taken from the reports and records of the Bureau of Foreign and Domestic Commerce:

Lead imported and entered for consumption in the United States, 1906–1915.

Year.	Lead in ore.		Base bullion.		Pigs, bars, and old.		Sheets, pipe, and shot.		Not otherwise specified.	Total value.
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.		
1906..	44,560,258	$755,545	587,731	$15,635	24,882,983	$960,998	346,177	$17,250	$4,503	$1,753,931
1907..	13,363,875	286,802	1,196,224	35,303	15,667,170	718,198	734,418	39,210	3,450	1,082,944
1908..	2,806,524	76,746	11,415,463	251,266	5,346,290	176,363	42,377	2,026	9,843	516,244
1909..	7,080,753	142,847	21,896,611	454,568	7,095,442	229,751	40,434	2,056	32,284	861,506
1910..	7,998,859	198,196	16,543,167	337,223	6,776,066	212,858	39,779	1,972	4,843	755,092
1911..	1,474,254	26,563	17,376,459	352,595	7,112,749	242,423	63,151	2,855	7,218	631,654
1912..	935,861	24,760	22,729,467	462,559	5,191,823	110,459	31,184	2,305	5,468	605,551
1913..	2,306,972	75,835	17,665,227	388,116	4,621,270	105,738	39,171	3,291	12,710	572,980
1914..	5,459,961	188,749	8,904,649	301,195	575,290	12,281	62,552	2,753	81,894	504,978
1915..	2,865,792	96,010	15,496,230	519,355	997,368	32,951	201,510	17,059	107,580	772,955

Type metal imported and entered for consumption in the United States, 1904–1915.

Year.	Type metal.		Lead content.[a]	
	Gross weight (pounds).	Value.	Quantity (pounds).	Percentage.
1904	8,143,749	$221,127	6,884,423	84.5
1905	13,932,013	456,155	11,476,629	82.4
1906	19,602,471	900,608	15,896,629	81.1
1907	14,832,673	932,027	12,095,027	81.5
1908	4,110,486	156,847	3,265,815	79.5
1909	13,993,889	532,108	11,339,378	81.0
1910	13,394,199	485,493	11,176,830	84.9
1911	8,390,470	310,658	6,936,711	82.7
1912	581,411	18,668	477,006	82.0
1913	567,004	20,098	467,688	82.5
1914	1,509,538	45,373	1,322,188	87.6
1915	2,768,261	107,607	2,424,306	87.6
Average lead content, 1904–1915				82.3

[a] Prior to 1904 the lead content of the type metal was not given. Besides lead, the chief constituent of the type metal is antimony.

General imports of lead into the United States, in ore, base bullion, and refined, 1908–1915, by sources, in pounds.

Country.	1909	1910	1911	1912	1913	1914	1915
United Kingdom	191,243	1,874,750	401,686	279,546	404,594	245,548	185,236
Germany	2,821,967	421,377	56,286	494,237	262,132	4,529,919	.....
Other European countries	1,385,616	418,669	111,189	55,356	143,293	123,085	32,537
Total from Europe..	4,398,826	2,714,796	569,161	829,139	810,019	4,898,552	217,773
British North America...	4,133,755	206,979	270,947	319,497	338,569	384,007	2,303,170
Mexico	215,203,714	203,290,307	172,633,479	159,455,664	95,693,439	46,282,207	94,247,384
South America	1,942,847	6,598,263	4,778,221	3,207,936	8,766,327	2,417,744	5,420,567
Other countries	2,683,950	4,394,421	1,651,544	3,309,356	8,685,612	2,694,293	802,516
Total imports	228,363,092	217,204,766	179,903,352	167,121,592	114,293,966	56,676,803	102,991,410

The large imports of lead credited to Germany in 1914 probably included lead from German East Africa, in previous years classed as from "Other countries," the imports from which are seen to have fallen off in 1914. The imports from Mexico in 1915 were more than double those of 1914, but still were less than half those of 1909 and 1910.

General imports of lead into the United States, 1910–1915, by classes, in pounds.

Year.	Lead in ore (lead content).	Base bullion.		Pigs, bars, sheets, and old.	Total lead content.
		Gross weight.	Lead content.		
1910	94,751,054	118,061,415	115,483,542	6,970,170	217,204,766
1911	35,686,180	141,481,852	138,952,372	5,264,800	179,903,352
1912	19,577,499	152,420,624	146,999,168	544,925	167,121,592
1913	19,883,313	96,908,170	94,327,654	82,999	114,293,966
1914	23,649,637	33,444,503	32,730,320	296,846	56,676,803
1915	18,185,140	86,247,995	83,986,988	819,282	102,991,410

Basic carbonate white lead, red lead, litharge, and orange mineral, imported and entered for consumption in the United States, 1911–1915.

Year.	Corroded white lead.		Red lead.		Litharge.		Orange mineral.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*		*Pounds.*		*Pounds.*	
1911	741,071	$46,213	1,063,533	$42,471	24,662	$1,196	504,734	$28,515
1912	687,705	46,494	757,908	33,854	32,443	1,550	334,551	20,914
1913	672,109	45,266	99,832	4,903	34,023	1,750	330,525	22,205
1914	596,567	40,203	12,554	2,934	33,651	1,805	240,388	16,388
1915	339,157	24,608	1,968	132	20,650	1,422	171,572	14,061

EXPORTS.

DOMESTIC EXPORTS.

The average difference between the prices of lead at New York and at London for the 10 years prior to 1914 was not far from 1½ cents per pound, the price at New York being the higher. This being the case, exports of domestic pig lead should be expected only under temporary or very unusual circumstances. The practice of the Bureau of Foreign and Domestic Commerce has been to class all exports of lead articles manufactured in this country as domestic exports, whether the lead be of domestic or foreign origin. For this reason no table of exports of domestic lead manufactures has been given, because such a table must have duplicated the table of foreign lead in manufactures exported with benefit of drawback. Since the exports of domestic pig lead began, however, they have been shown separately.

In 1914 the price of lead at London rose above the price at New York early in January and consistently remained between one-fourth and one-half cent per pound above throughout the year. This made it possible to export domestic lead at a profit, and the decrease in imports of lead ore and bullion from Mexico rendered it necessary to satisfy the foreign demand with domestic lead, the exports of which

assumed large proportions. The movement commenced in March, 1914, and by the close of the year 58,722 short tons, valued at $4,501,674, had been exported. Likewise in 1915 the price of lead at London was from one-fourth to 1 cent a pound higher than the price at New York, except for the period of high prices in the United States during June and July. Exports of domestic lead continued heavy throughout the year, reaching a total of 87,092 tons, valued at $7,796,998. The exports were probably held down to a certain extent by the lack of shipping facilities. The quantity exported by months and the destination are given on page 196.

FOREIGN EXPORTS.

By foreign lead exports is meant the exports of lead of foreign origin which has been smelted, refined, or manufactured in this country and then shipped abroad. The following table, made up from the records of the Bureau of Foreign and Domestic Commerce, shows the total lead exported for a period of years; but it must be borne in mind, as pointed out on a previous page, that prior to 1915 the actual exports were not in the form shown in the table, which is the import form, but instead consisted of refined lead and lead manufactures. Since July 1, 1915, the exports of foreign lead heretofore classed as "ore," "base bullion," and "pigs, bars, and old" are all included in "pigs, bars, and old" as domestic manufactures of lead from foreign ore. The quantities of lead exported from warehouse are exact, but the quantities given of lead in manufactures are subject to the waste in manufacturing.

Foreign lead exported from the United States, 1910–1915.

Year.	Exported from warehouse.							Exported in manufactures with benefit of drawbacks.	
	Lead content ore.		Lead content base bullion.		Pigs, bars, and old.		All other manufactures.	Lead content ore.	Pigs, bars, bullion, and old.
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Value.	Quantity (pounds).	Quantity (pounds).
1910	22,508,090	$248,220	117,045,333	$2,262,057	19,507	$703	$870	6,592,294	11,008,604
1911	39,276,820	730,247	151,986,265	3,093,290	12,311,102	244,037	1,504	674,621	23,485,929
1912	12,796,703	219,859	116,907,305	2,478,256	107,170	3,826	2,121	150,617	22,584,221
1913	11,721,714	271,985	77,253,891	1,827,538	111,506	4,851	3,422	74,628	19,484,345
1914	6,724,525	245,205	10,944,350	378,286	25,421,500	913,306	2,242	4,153,018	14,722,213
1915	(a)	.....	(a)	.....	76,890,712	2,731,692	40,112	a 7,966,302	

a Since July 1, 1915, the Bureau of Foreign and Domestic Commerce has classed all foreign lead exported as "domestic exports, of pigs, bars, etc., produced from foreign."

CONSUMPTION.

In statements of consumption of lead in these reports prior to 1907 it was the custom to take into account the smelter stocks of lead at the beginning and at the close of the year. It is not to be denied that for the individual year this gives closer figures. It is just as true that account of trade stocks should also be taken to arrive at accurate results; but this is manifestly outside the scope of this Survey. It has been found impossible to obtain a statement of stocks

from one large producer since 1906; hence consumption has been calculated without reference to domestic stocks. A very considerable part, however, amounting to between one-fourth and one-fifth of the lead smelted and refined in this country, is lead of foreign origin smelted in bond, and it is possible to obtain the stocks of this portion, since they are reported annually by the Bureau of Foreign and Domestic Commerce as "merchandise remaining in warehouse at close of year." A certain element of error is introduced by the fact that the imports, the exports, and the warehouse stocks, as given, include lead in both ore and base bullion. So far as imports are concerned, the relative quantities of lead in ore and of base bullion are shown on a preceding page in the table entitled "Imports of lead, by classes," based upon the records of the Bureau of Foreign and Domestic Commerce, and corroborated in the preceding table giving the "sources of primary lead smelted or refined in the United States," based upon smelter reports. For exports and warehouse stocks no such division can be made, because the classes used therein represent the condition of the metal when imported and do not change with the reduction of the metal in bond. Nevertheless, it is deemed advisable to use warehouse stocks as giving a better estimate of consumption. It is necessary, therefore, to include all classes of lead imports as well as all classes of lead exports.

In the following table "lead" includes all kinds—lead in ore, base bullion, pigs, bars, and old. The figures of domestic production are based upon the returns by the smelters; all other figures are from the records of the Bureau of Foreign and Domestic Commerce. Decrease by liquidation covers losses in smelting and refining in bond and other corrections. Because warehouse stocks are used in lieu of smelter stocks the result given below is lead "available for consumption." The "apparent consumption" of previous reports would be this quantity increased or diminished by the increase or decrease of domestic stocks during the year.

Primary lead available for consumption in the United States, 1909–1915, in short tons.

	1909	1910	1911	1912	1913	1914	1915
Supply:							
Stock in bonded warehouse, Jan. 1..	18,565	17,405	35,972	4,481	10,492	5,310	7,668
Imports:							
For consumption	18,036	15,359	13,281	14,146	11,980	7,386	9,680
For warehouse	96,145	93,249	76,671	69,414	45,165	20,952	41,816
Increase by liquidation							2,250
Production from domestic ores	352,839	375,402	391,995	392,517	411,878	512,794	507,026
Apparent supply	485,585	501,415	517,919	480,558	479,515	546,442	568,440
Withdrawn:							
Exports of foreign lead:							
From warehouse	86,077	69,786	101,227	64,906	44,544	21,545	38,445
In manufactures, with benefit of drawback	4,796	8,800	12,080	11,320	9,779	9,438	3,983
Exports of domestic lead						58,722	87,092
Decrease by liquidation	8,643	7,661	14,812	5,692	419	56	
Stock in bonded warehouse Dec. 31.	17,405	35,972	4,481	10,492	5,310	7,668	12,169
Total withdrawn	116,921	122,219	132,600	92,410	60,052	97,429	141,689
Available for consumption	368,664	379,196	385,319	388,148	419,463	449,013	426,751

Owing to the war no statistics of consumption of lead in European countries have been published since 1913. For these figures consult the chapter on lead in Mineral Resources of the United States, 1913.

PRICES AND VALUE.

PRICES.

Lead began the year at New York with a price of 3.8 cents a pound, nearly the minimum price of the year, and remained practically stationary until the middle of February. A gradual rise brought the price to 4.2 cents in April, and it remained there until the latter part of May. A rapid rise next followed, and lead reached the maximum for the year at 7.56 cents on June 14. A sharp decline, followed by partial recovery and then by a more general decline, brought the price to 4.4 cents in the latter part of August. After a slight recovery and another decline to 4.45 cents in September, the price gradually rose and closed the year at 5.5 cents. The average price at New York for the year was 4.7 cents a pound, compared with 3.9 cents in 1914 and 4.4 cents in 1913. These are the figures used in calculating the value of the production of lead in the United States for those years.

The price of lead at London started at £19 a long ton (4.1 cents a pound) and rose until the latter part of March, when it reached £23 2s. 6d. a long ton (5 cents a pound). From this point the price fell to £20 1s. 3d. a long ton (4.3 cents a pound), after which there was a sharp ascent to £28 2s. 6d. (6.1 cents a pound) at the middle of June. After several ups and downs the price dropped to £20 6s. 3d. (4.4 cents a pound) by the middle of August, and then a gradual rise carried it to £29 5s. a long ton (6.3 cents a pound). It closed the year at £30 2s. 6d. per long ton (6.5 cents a pound). The London market was fairly parallel to the New York market and, except for the period of high prices in the United States during June and July, was uniformly higher than the American market.

PRICE CURVES.

The fluctuations in the price of lead at New York and London are graphically shown in figure 3, which gives curves of the weekly average price of lead in those markets for the years 1914 and 1915.

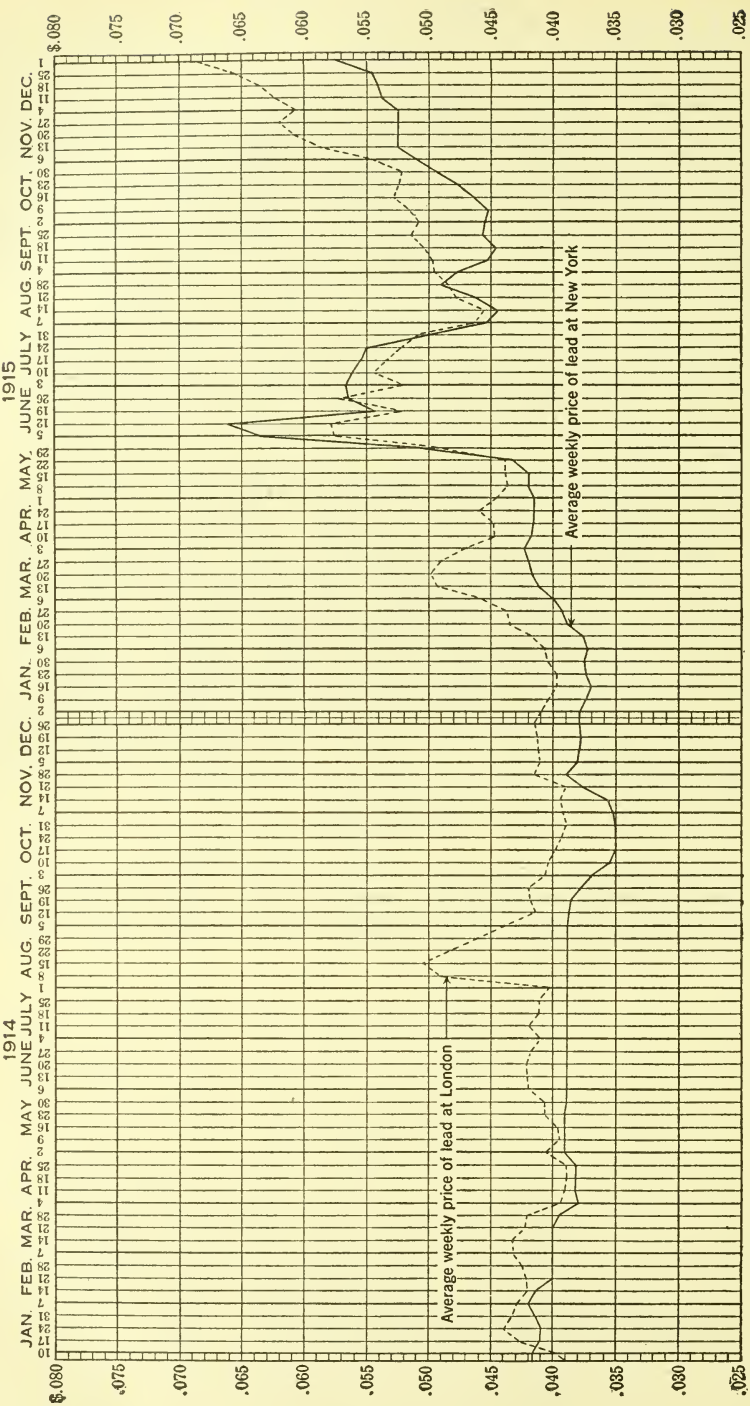

FIGURE 3.—Average weekly price of lead at New York and London in 1914 and 1915.

VALUE.

The output of refined lead in the United States from domestic ores in 1915 was 507,026 short tons, valued at $47,660,000, at the average price of refined lead in New York, as compared with 512,794 tons, valued at $39,998,000, at the average price at New York in 1914, a loss in quantity of 5,768 tons, about 1 per cent, and a gain in value of $7,662,000, nearly 20 per cent.

CANADIAN LEAD BOUNTY.

The price of lead in London during the whole fiscal year, 1915–16, ending March 31, except the first two months, was above the maximum at which bounty is granted, £18 per long ton (3.91 cents per pound); hence there was very little bounty due to producers. The actual amount paid has not yet been made public.

BIBLIOGRAPHY.

A list of the more important publications on lead and zinc published by the United States Geological Survey is given in the chapter on zinc in Mineral Resources, 1915.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN CALIFORNIA.

(MINES REPORT.)

By Charles G. Yale.

PRODUCTION.

GENERAL STATEMENT.

Number of mines producing in California, quantity of ore sold or treated, and total gold, silver, copper, lead, and zinc produced in 1905–1915.

Year.	Number of mines producing.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.	*Value.*	*Fine ozs.*	*Pounds.*	*Pounds.*	*Pounds.*	
1905	1,139	2,696,603	$18,898,545	1,076,174	16,697,544	447,723	.....	$22,174,413
1906	1,017	2,556,056	18,732,452	1,220,641	28,726,448	338,718	206,000	25,126,359
1907	1,061	2,054,653	16,727,928	1,138,858	28,528,020	2,625,419	233,550	23,338,104
1908	1,054	2,546,908	18,761,559	1,647,278	38,776,881	1,237,548	.....	24,805,141
1909	1,127	3,041,688	20,237,870	2,098,253	57,288,281	1,502,597	.....	28,841,050
1910	1,079	2,697,885	19,715,440	1,840,085	48,700,756	2,870,977	.....	27,020,405
1911	1,181	2,797,261	19,738,908	1,270,445	36,316,136	1,398,111	2,807,035	25,174,677
1912	1,041	2,641,497	19,713,478	1,300,136	33,451,672	1,144,731	4,345,591	26,383,946
1913	796	2,495,958	20,406,958	1,378,399	34,575,007	3,514,342	1,057,485	26,812,487
1914	658	2,465,485	20,653,496	1,471,859	30,507,692	4,251,923	389,471	25,710,645
1915	608	3,002,779	22,442,296	1,678,756	40,751,625	4,579,245	13,094,032	32,263,844
Increase or decrease, 1915	−50	+537,294	+1,788,800	+206,897	+10,243,933	+327,322	+12,704,561	+6,553,199

There was a decrease in California in 1915 in number of productive mines but an increase in yield of gold, silver, copper, lead, and zinc, the total value for the year being $6,553,199 more than in 1914.

In this table and in other tables in this chapter in which separate counties are considered, the value for gold and the quantity of silver bear no relation to the quantity of ore, for the deep-mine gold and silver and the placer-mine gold and silver are combined under the respective headings of these metals. Other tables are provided, however, to show the details. For example, in the preceding table the total output of gold for 1915 is shown as $22,442,296, of which $13,833,679 was derived from deep mines and $8,608,617 from placers. In the same way, of the total output of silver of 1,678,756 fine ounces, 1,640,888 fine ounces were from deep mines and 37,868 fine ounces were from placers. Under head of producing mines both deep mines and placer mines are enumerated.

In 1915 there were 608 properties reporting production, of which 321 were deep mines and 287 were placers. The producing deep mines

of 1915 may be classified by chief metallic product as follows: Gold, 237; copper, 43; silver, 11; silver-lead, 3; lead, 21; and zinc, 6. Of the placer mines 96 were hydraulic—9 less than in 1914; 58 were dredge—2 less than in 1914; 61 were drift—9 less than in 1914; and 72 were surface or sluicing mines—33 less than in 1914. There were altogether 53 less placer mines producing than in 1914. Of deep mines there were 40 less gold mines, 24 more copper, 4 more silver, 3 less silver-lead, 12 more lead, and 6 more zinc; there were therefore 3 more deep mines productive than in 1914. The dredges are enumerated by number of boats at work, some companies owning only one, and others several.

The 321 deep mines producing in 1915 made an output of 3,002,779 tons of ore, or 537,294 tons more than in 1914. Of this output 2,367,912 tons were siliceous ore; 601,815 tons, copper ore; 12,822 tons, lead ore; 440 tons, silver ore; 144 tons, silver-lead ore; and 19,646 tons, zinc ore. The siliceous ore increased by 317,575 tons, the copper ore by 203,947 tons, the lead ore by 12,822 tons, and the zinc ore by 19,646 tons. The silver ore decreased by 20 tons, and the silver-lead ore by 16,036 tons.

The siliceous ore yielded an average per ton in gold and silver of $5.68; the copper ore, $1.71; the silver ore, $63.77; the lead ore, $6.85; the silver-lead ore, $64.32; and the zinc ore, $3.09. The average per ton in gold and silver from all ores treated in the State in 1915 was $4.89.

The 3,002,779 tons of ore of all classes treated in California in 1915 yielded 669,204.22 fine ounces of gold, valued at $13,833,679; 1,640,888 fine ounces of silver, valued at $831,930; 40,751,625 pounds of copper, valued at $7,131,534; 4,579,245 pounds of lead, valued at $215,225; and 13,094,032 pounds of zinc, valued at $1,623,660.

The value of all metals obtained from ore mined and treated in California in 1915 was $23,636,028, an average of $7.87 a ton. In 1914 the output from ore was valued at $16,610,509, an average of $6.74 a ton. In 1913 the value was $17,954,941 and the average was $7.19. In 1912 the figures were, respectively, $17,716,357 and $6.71; in 1911, $16,167,193 and $5.49; in 1910, $18,109,008 and $6.71; in 1909, $19,715,314 and $6.48; and in 1908, $16,536,226 and $6.49.

In 1915 there was treated at gold and silver mills, 2,286,569 tons of ore, yielding altogether $12,622,460 in gold, an average value of $5.52 a ton, and 195,083 fine ounces of silver, valued at $98,907, an average of 4 cents a ton, a total value of $12,721,367 in gold and silver, an average value per ton of $5.56 in both metals. The average value per ton in 1914 was $5.44; in 1913, $5.57; in 1912, $5.08; in 1911, $4.64; in 1910, $5.25; in 1909, $4.88; and in 1908, $5.08.

There was recovered in 1915 as bullion in the mills $10,227,718 in gold, averaging $4.47 a ton, and 171,943 fine ounces of silver, valued at $87,175, averaging 4 cents a ton, a total of $10,314,893 in gold and silver, averaging $4.51 a ton in both metals.

From 2,286,569 tons of gold milling ore, 44,444 tons of concentrates were obtained, containing $2,394,742 in gold, an average of $53.89 a ton, and 23,140 ounces of silver, valued at $11,732, an average of 26 cents a ton. This was a yield in gold and silver of $2,406,474, or an average value recovered from the concentrates of $54.15 a ton.

Of smelting ores 706,371 tons were shipped, having an output of gold of $1,186,929, an average of $1.68, and of 1,445,037 ounces of

silver, valued at $732,634, an average recovery of $1.04. The total yield of gold and silver was $1,919,563, or an average of $2.72 a ton.

There were treated also 9,808 tons of old tailings, yielding $24,290 in gold, an average of $2.48 a ton, and 768 ounces of silver, valued at $389, an average of 4 cents a ton. The total gold and silver produced from the tailings was valued at $24,679, an average of $2.52 a ton.

The 287 productive placer mines in California in 1915 yielded 416,441.85 fine ounces of gold, valued at $8,608,617, and 37,868 ounces of silver, valued at $19,199, a total value of $8,627,816. This was $472,320 less than the output of 1914. The decrease of gold was $472,232 and the decrease of silver was $88. In production of gold the dredge properties showed an increase of $13,071, the hydraulic mines showed a decrease of $282,114, the drift mines a decrease of $56,993, and the surface placer or sluicing mines a decrease of $146,196. The decrease of gold from the hydraulic, drift, and surface placers was $485,303, so that the increase in dredge yield failed to offset the decrease in the other classes of placers by $472,232.

Mine production of gold, silver, copper, lead, and zinc in California, 1915.

County.	Ore treated.	Deep-mine gold.		Placer gold.		Total gold.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.	*Fine ounces.*		*Fine ounces.*		*Fine ounces.*	
Amador	819,698	188,027.14	$3,886,866	351.15	$7,259	188,378.29	$3,894,125
Butte	47	223.01	4,610	74,563.58	1,541,366	74,786.59	1,545,976
Calaveras	418,656	46,622.66	963,776	20,673.44	427,358	67,296.10	1,391,134
Del Norte				49.25	1,018	49.25	1,018
Eldorado	21,431	4,810.80	99,448	14,601.51	301,840	19,412.31	401,288
Fresno	672	176.72	3,653	24.09	498	200.81	4,151
Humboldt	31			771.44	15,947	771.44	15,947
Imperial	5,545	695.10	14,369			695.10	14,369
Inyo	57,974	15,378.66	317,905			15,378.66	317,905
Kern	199,028	47,311.67	978,019	256.39	5,300	47,568.06	983,319
Lake, Merced, Stanislaus	50	36.28	750	13,239.51	273,685	13,275.79	274,435
Madera	2,048	516.50	10,677	25.98	537	542.48	11,214
Mariposa	48,848	18,612.62	384,757	39.67	820	18,652.29	385,577
Modoc	303	365.57	7,557			365.57	7,557
Mono	5,866	5,190.73	107,302			5,190.73	107,302
Nevada	315,983	165,852.96	3,428,485	1,849.71	38,237	167,702.67	3,466,722
Placer	83,110	8,909.90	184,184	11,132.78	230,135	20,042.68	414,319
Plumas	80,037	5,221.89	107,946	2,878.02	59,494	8,099.91	167,440
Riverside	1,321	520.95	10,769			520.95	10,769
Sacramento				103,126.45	2,131,813	103,126.45	2,131,813
San Bernardino	51,675	20,130.77	416,140	40.01	827	20,170.78	416,967
San Diego	44	65.98	1,364			65.98	1,364
Shasta	544,272	50,161.15	1,036,923	4,059.87	83,925	54,221.02	1,120,848
Sierra	80,080	32,021.06	661,934	3,116.70	64,428	35,137.76	726,362
Siskiyou	1,397	1,816.53	37,551	18,825.86	389,165	20,642.39	426,716
Trinity	15,632	5,527.71	114,268	15,846.59	327,578	21,374.30	441,846
Tuolumne	248,942	50,973.76	1,053,721	211.98	4,382	51,185.74	1,058,103
Yuba	89	34.10	705	130,757.87	2,703,005	130,791.97	2,703,710
	3,002,779	669,204.22	13,833,679	416,441.85	8,608,617	1,085,646.07	22,442,296
Total, 1914	2,465,485	559,826.80	11,572,647	439,286.07	9,080,849	999,112.87	20,653,496
Increase or decrease	+537,294	+109,377.42	+2,261,032	−22,844.22	−472,232	+86,533.20	+1,788,800

Mine production of gold, silver, copper, lead, and zinc in California, 1915—Continued.

County.	Deep-mine silver.		Placer silver.		Total silver.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Fine ounces.		*Fine ounces.*		*Fine ounces.*	
Amador	40,191	$20,377	63	$32	40,254	$20,409
Butte	568	288	6,203	3,145	6,771	3,433
Calaveras	102,847	52,143	2,278	1,155	105,125	53,298
Del Norte			12	6	12	6
Eldorado	961	487	1,708	866	2,669	1,353
Fresno	481	244	4	2	485	246
Humboldt			122	62	122	62
Imperial	83	42			83	42
Inyo	252,257	127,894			252,257	127,894
Kern	26,225	13,296	40	20	26,265	13,316
Lake, Merced, Stanislaus	6	3	3,068	1,555	3,074	1,558
Madera	4,187	2,123	6	3	4,193	2,126
Mariposa	4,280	2,170	10	5	4,290	2,175
Modoc	205	104			205	104
Mono	3,793	1,923			3,793	1,923
Nevada	46,610	23,631	258	131	46,868	23,762
Placer	46,911	23,784	1,497	759	48,408	24,543
Plumas	37,097	18,808	428	217	37,525	19,025
Riverside	3,002	1,522			3,002	1,522
Sacramento			6,215	3,151	6,215	3,151
San Bernardino	126,552	64,162	6	3	126,558	64,165
San Diego	18	9			18	9
Shasta	905,946	459,315	495	251	906,441	459,566
Sierra	5,872	2,977	353	179	6,225	3,156
Siskiyou	1,700	862	2,404	1,219	4,104	2,081
Trinity	4,690	2,378	2,154	1,092	6,844	3,470
Tuolumne	26,400	13,385	187	95	26,587	13,480
Yuba	6	3	10,357	5,251	10,363	5,254
	1,640,888	831,930	37,868	19,199	1,678,756	851,129
Total, 1914	1,436,982	794,651	34,877	19,287	1,471,859	813,938
Increase or decrease	+203,906	+37,279	+2,991	−88	+206,897	+37,191

County.	Copper.		Lead.		Zinc.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Amador	4,183	$732					$3,915,266
Butte							1,549,409
Calaveras	3,789,932	662,238					2,107,670
Del Norte							1,024
Eldorado							402,641
Fresno	65,612	11,482					15,879
Humboldt	6,468	1,132					17,141
Imperial							14,411
Inyo	151,768	26,559	4,347,967	$204,355	4,656,427	$577,397	1,254,110
Kern	1,571	275	47,574	2,236			999,146
Lake, Merced, Stanislaus	4,286	750					276,743
Madera	152,502	26,688					40,028
Mariposa	136,445	23,878					411,630
Modoc							7,661
Mono							109,225
Nevada							3,490,484
Placer	1,979,309	346,379					785,241
Plumas	3,122,503	546,438	4,256	200			733,103
Riverside	20,772	3,635	116,021	5,453			21,379
Sacramento							2,134,964
San Bernardino	135,030	23,630	63,427	2,981	39,847	4,941	512,684
San Diego	3,000	525					1,898
Shasta	30,787,846	5,387,873			8,397,758	1,041,322	8,009,609
Sierra							729,518
Siskiyou	86,611	15,157					442,954
Trinity	300,787	52,638					497,954
Tuolumne	3,000	525					1,072,108
Yuba							2,708,964
	40,751,625	7,131,534	4,579,245	215,225	13,094,032	1,623,660	32,263,844
Total, 1914	30,507,692	4,057,523	4,251,923	165,825	389,471	19,863	25,710,645
Increase or decrease	+10,243,933	+3,074,011	+327,322	+49,400	+12,704,561	+1,603,797	+6,553,199

GOLD.

The total production of gold in California in 1915 was 1,085,646.07 fine ounces, valued at $22,442,296, an increase of 86,533.20 fine ounces, valued at $1,788,800, or about 9 per cent increase for 1915. The deep mines of the State yielded 669,204.22 fine ounces of gold, valued at $13,833,679. Of the deep-mine gold 96.2 per cent was derived from siliceous ore; 3.5 per cent was derived from copper ore; 0.2 per cent from lead ore; and the remainder from silver ore, silver-lead ores, and zinc ores.

The placer yield of gold in 1915 was 416,441.85 fine ounces, valued at $8,608,617, derived from 96 hydraulic mines, 58 dredges, 61 drift mines, and 72 surface or sluicing mines. The placer mines produced 38 per cent of the total gold yield for 1915 and the deep mines 62 per cent, as compared with 44 per cent for the placers and 56 for the deep mines in 1914. The dredges produced 35 per cent of the total gold yield from all sources in 1915. Of the total placer gold the dredges produced 90.5 per cent, the hydraulic mines 5 per cent, the drift mines 3.1 per cent, and the surface or sluicing mines 1.4 per cent. The three larger and more important dredging fields of the State are at Oroville, Butte County; Folsom, Sacramento County; and Marysville, Yuba County. Dredges are also operated in eight other counties—5 in Calaveras, 1 in Eldorado, 1 in Merced, 2 in Stanislaus, 3 in Placer, 2 in Shasta, 2 in Siskiyou, and 2 in Trinity. The Yuba County dredges, 12 in number, made the largest output of gold, the value being $2,676,090, a decrease of $79,644. Sacramento County, with 11 dredges at work, made an output of $2,129,787, a decrease of $31,866. In Butte County (including Oroville and "outside" districts), 17 dredges produced $1,491,066 in gold, or $146,449 less than in 1914. This statement shows that $257,959 less gold was obtained in these three districts than in 1914, but the other districts of the State increased the total dredge output by $13,071 in 1915 over 1914.

Of the 30 counties producing gold in 1915 in California, 8 yielded no placer gold and 4 yielded no gold from deep mines. Eight counties produced more than $1,000,000 each in gold in 1915 as follows: Amador, $3,894,125; Nevada, $3,466,722; Yuba, $2,703,710; Sacramento, $2,131,813; Butte, $1,545,976; Calaveras, $1,391,134; Shasta, $1,120,848; and Tuolumne, $1,058,103. The leading hydraulic mining county was Siskiyou; the greatest producer of gold from drift mines was Placer; the largest producer of gold from dredges was Yuba; and the largest producer from surface or sluicing mines was Butte. The largest increase, $812,123, in total yield of gold in 1915, as compared with 1914, was in Amador, which was followed by Kern with $388,982, Eldorado with $267,402, Mariposa with $254,119, San Bernardino with $207,495, and Nevada with $164,774. Some counties showed a decreased yield of gold for 1915, as Trinity, $301,666; Imperial, $196,059; Placer, $182,893; Butte, $151,144; and others with smaller amounts.

Mine production of gold in California in 1915, by sources, in fine ounces.

County.	Placers.	Deep mines.							Grand total.
		Siliceous ores.	Copper ores.	Lead ores.	Silver ores	Silver-lead ores.	Zinc ores.	Total.	
Amador	351.15	188,012.68	14.46					188,027.14	188,378.29
Butte	74,563.58	223.01						223.01	74,786.59
Calaveras	20,673.44	43,172.55	3,450.11					46,622.66	67,296.10
Del Norte	49.25								49.25
Eldorado	14,601.51	4,810.80						4,810.80	19,412.31
Fresno	24.09	134.00	42.72					176.72	200.81
Humboldt	771.44								771.44
Imperial		695.10						695.10	695.10
Inyo		14,142.82	4.02	1,104.84			126.98	15,378.66	15,378.66
Kern	256.39	47,266.68			19.98	25.01		47,311.67	47,568.06
Lake, Merced, and Stanislaus	13,239.51		36.28					36.28	13,275.79
Madera	25.98	485.49	31.01					516.50	542.48
Mariposa	39.67	18,591.53	21.09					18,612.62	18,652.29
Modoc		365.57						365.57	365.57
Mono		5,190.73						5,190.73	5,190.73
Nevada	1,849.71	165,852.96						165,852.96	167,702.67
Placer	11,132.78	4,609.94	4,299.96					8,909.90	20,042.68
Plumas	2,878.02	4,738.97	482.73			.19		5,221.89	8,099.91
Riverside		405.96	114.99					520.95	520.95
Sacramento	103,126.45								103,126.45
San Bernardino	40.01	19,968.96	76.38	5.42	76.00	4.01		20,130.77	20,170.78
San Diego		65.98						65.98	65.98
Shasta	4,059.87	35,248.30	14,912.85					50,161.15	54,221.02
Sierra	3,116.70	32,021.06						32,021.06	35,137.76
Siskiyou	18,825.86	1,810.53	6.00					1,816.53	20,642.39
Trinity	15,846.59	5,227.69	300.02					5,527.71	21,374.30
Tuolumne	211.98	50,968.78	4.98					50,973.76	51,185.74
Yuba	130,757.87	34.10						34.10	130,791.97
Total	416,441.85	644,044.19	23,797.60	1,110.26	95.98	29.21	126.98	669,204.22	1,085,646.07
Total, 1914	439,286.07	541,743.93	16,630.16	35.37	71.69	1,345.65		559,826.80	999,112.87
Increase or decrease	−22,844.22	+102,300.26	+7,167.44	+1,074.89	+24.29	−1,316.44	+126.98	+109,377.42	+86,533.20

From the siliceous ore and old tailings the recovery of gold by methods of treatment in California in 1915 was as follows: By amalgamation, 419,268.45 fine ounces, valued at $8,667,048; by cyanidation, 76,672.44 fine ounces, valued at $1,584,960; by chlorination, $452,260. Gold valued at $1,186,929 was obtained from smelting crude ore, and $1,942,482 was obtained from concentrates treated at custom reduction plants and smelters. The figures of recovery by cyanidation are approximate only, for the reason that the returns received from some individual mines do not segregate the recovery by sources. Some of the very largest deep-mine gold producers, for instance, pass the ore from the amalgamating mills direct through their cyanide plants, and give their total recovery without accounting for the quantity saved by separate systems of treatment. The same is the case with many smaller operators. Indeed, most of them do not keep any separate accounts, and do not therefore report to the Survey. There are two properties in the State which use the direct cyanidation process without amalgamation—the Black Oak, at Soulsbyville, Tuolumne County, and the Globe Consolidated, at Dedrick, Trinity County. There are also two companies owning their own chlorination plants—the Kennedy, at Jackson, Amador County, and the Eagle Shawmut, at Shawmut, Tuolumne County.

Value and source of placer gold mined in California in 1915.

County.	Hydraulic.	Dredging.	Drift.	Surface placers.	Total.
Amador	.....	.....	$5,807	$1,452	$7,259
Butte	$5,644	$1,491,066	13,746	30,910	1,541,366
Calaveras	.....	371,667	51,961	3,730	427,358
Del Norte	481	.....	.....	537	1,018
Eldorado	.....	278,966	14,236	8,638	301,840
Fresno	.....	.....	.....	498	498
Humboldt	15,740	.....	.....	207	15,947
Kern	.....	.....	3,000	2,300	5,300
Madera	.....	.....	.....	537	537
Mariposa	.....	.....	.....	820	820
Merced and Stanislaus	.....	272,634	1,051	.....	273,685
Nevada	4,272	.....	31,465	2,500	38,237
Placer	465	93,812	120,648	15,210	230,135
Plumas	29,698	.....	8,247	21,549	59,494
Sacramento	.....	2,129,787	2,026	.....	2,131,813
San Bernardino	.....	.....	.....	827	827
Shasta	1,282	80,307	.....	2,336	83,925
Sierra	44,177	.....	13,282	6,969	64,428
Siskiyou	171,377	214,511	1,917	1,360	389,165
Trinity	136,120	187,625	1,600	2,233	327,578
Tuolumne	.....	.....	3,969	413	4,382
Yuba	11,514	2,676,090	.....	15,401	2,703,005
	420,770	7,796,465	272,955	118,427	8,608,617

SILVER.

The mine yield of silver in California in 1915 was 1,678,756 fine ounces, valued at $851,129, an increase in quantity of 206,897 ounces, and in value of $37,191. The larger portion of the output 1,445,037 ounces, valued at $732,634, was derived from crude smelting ores. Siliceous ore, milled and smelted, yielded 272,849 fine ounces, valued at $138,334. The largest output of silver came, as usual, from Shasta County, which produced from copper ores 860,057 ounces, valued at $436,049; from siliceous ore, 45,889 ounces, valued at $23,266; and from placers, 495 fine ounces, valued at $251—a total

yield from the county in silver of 906,441 fine ounces, valued at $459,566. In 1914 the county produced 626,954 ounces, valued at $346,706. Inyo County followed Shasta in yield of silver, the output being 252,257 ounces, valued at $127,894, a decrease as compared with 1914 of 214,318 ounces in quantity and of $130,122 in value. This was nearly equally divided between lead ores and zinc ores. The total silver derived from deep mines of all classes in California in 1915 was 1,640,888 ounces, valued at $831,930. The silver obtained with gold in placer mining in the State in 1915 was 37,868 ounces, valued at $19,199. The largest producer of placer silver was Yuba County—10,357 ounces, valued at $5,251.

Mine production of silver in California in 1915, by sources, in fine ounces.

County.	Placers.	Deep mines.							Grand total.
		Siliceous ores.	Copper ores.	Lead ores.	Silver ores.	Silver-lead ores.	Zinc ores.	Total	
Amador	63	39,733	458					40,191	40,254
Butte	6,203	568						568	6,771
Calaveras	2,278	9,626	93,221					102,847	105,125
Del Norte	12								12
Eldorado	1,708	961						961	2,669
Fresno	4	14	467					481	485
Humboldt	122								122
Imperial		83						83	83
Inyo		6,277	6,400	125,292			114,288	252,257	252,257
Kern	40	14,349			4,935	6,941		26,225	26,265
Lake, Merced, and Stanislaus	3,068		6					6	3,074
Madera	6	33	4,154					4,187	4,193
Mariposa	10	3,144	1,136					4,280	4,290
Modoc		205						205	205
Mono		3,793						3,793	3,793
Nevada	258	46,610						46,610	46,868
Placer	1,497	1,152	45,759					46,911	48,408
Plumas	428	654	36,095	29		319		37,097	37,525
Riverside		243	183	2,576				3,002	3,002
Sacramento	6,215								6,215
San Bernardino	6	63,328	6,460	61	46,493	9,816	394	126,552	126,558
San Diego		18						18	18
Shasta	495	45,889	860,057					905,946	906,441
Sierra	353	5,872						5,872	6,225
Siskiyou	2,404	1,230	470					1,700	4,104
Trinity	2,154	2,690	2,000					4,690	6,844
Tuolumne	187	26,371	29					26,400	26,587
Yuba	10,357	6						6	10,363
	37,868	272,849	1,056,895	127,958	51,428	17,076	114,682	1,640,888	1,678,756
Total, 1914	34,877	203,413	703,042	17,058	65,415	448,054		1,436,982	1,471,859
Increase or decrease	+2,991	+69,436	+353,853	+110,900	−13,987	−430,978	+114,682	+203,906	+206,897

From the siliceous ore and old tailings treated in California in 1915 the recovery of silver by amalgamation was 101,036 fine ounces, valued at $51,225; by cyanidation, 71,675 fine ounces, valued at $36,339; by chlorination, 3,747 ounces, valued at $1,900; and from smelting ores, 1,445,037 fine ounces, valued at $732,634. The production from concentrates treated at custom mills and smelters was 19,393 fine ounces, valued at $9,832.

COPPER.

The mine production of copper in California in 1915 was 40,751,625 pounds, valued at $7,131,534, an increase of 10,243,933 pounds and of $3,074,011 over the production of 1914. Copper was produced in Amador, Calaveras, Fresno, Humboldt, Inyo, Kern, Lake, Madera, Mariposa, Placer, Plumas, Riverside, San Bernardino, San Diego, Shasta, Siskiyou, Trinity, and Tuolumne counties. The heaviest production, as usual, came from Shasta County, which produced 30,787,846 pounds, valued at $5,387,873, an increase of 5,589,177 pounds in quantity and of $2,036,450 in value. Altogether there were 601,815 tons of copper ore treated in 1915, or 203,947 more than in 1914. The smelter of the Mammoth Copper Co. continues to be the only one in operation in Shasta County, the others remaining closed owing to smelter-fume injunctions. The Mountain Copper Co. of that county ships the ore from its mines to the company's smelter on the shores of San Francisco Bay, near Martinez. The Balaklala ore was sold to the Mammoth Copper Co., as was that of the Bully Hill Co. The Mammoth Co. also treated considerable ore from small sulphide mines in different parts of the county. The Engels Copper Co., in Plumas County, concentrates its ore by oil flotation, shipping the concentrates to Salt Lake City smelters. The Calaveras Copper Co., Cavaleras County, ships its high-grade ore to a smelter and its low-grade ore is treated by oil flotation, the concentrates being shipped. The Penn Co., of Calaveras County, has its own 200-ton smelter and ships the matte to New York for refining. The copper ores of California in 1915 yielded, in addition to the copper, 23,797.60 fine ounces of gold, valued at $491,940, and 1,056,895 ounces of silver, valued at $535,846.

LEAD.

The mine production of lead in California in 1915 was 4,579,245 pounds, valued at $215,225, as compared with 4,251,923 pounds, valued at $165,825, in 1914. From the lead ore was obtained also 1,110.26 fine ounces of gold, valued at $22,951, and 127,958 ounces of silver, valued at $64,875. The total value of the output from the lead-mining industry of the State in 1915, in lead and contained value of gold and silver, was $303,051. This refers to ores classified as lead ores only, and does not consider the gold and silver obtained from those ores classified as silver-lead. Most of the lead was derived from Inyo County, although there was a considerable quantity from Riverside, San Bernardino, and Kern counties, and a less quantity from Plumas County.

ZINC.

The recoverable mine production of zinc in California in 1915 was 13,094,032 pounds, valued at $1,623,660, as compared with 389,471 pounds, valued at $19,863, in 1914, an increase for 1915 of 12,704,561

pounds in quantity and $1,603,797 in value. There are now six producing zinc mines in the State, the principal ones being in Shasta, Inyo, and San Bernardino counties. The production of zinc in 1915 is the record one for the State, the yield being 8,748,441 pounds in excess of the quantity for the highest previous year.

MINING AND METALLURGICAL INDUSTRIES IN CALIFORNIA IN 1915.

The total value of the gold, silver, copper, lead, and zinc produced in California in 1915 shows an increase of 25.5 per cent. There was an increase in quantity and value in all the metals, the most marked being in copper, gold, and zinc, in the order named. In copper the increase was 34 per cent in quantity and 75 per cent in value; in gold it was 9 per cent; and in zinc it was 326 per cent in quantity and 807 per cent in value. The lead output increased 8 per cent in quantity and 29 per cent in value. The increase in silver was 14 per cent in quantity and 4.5 per cent in value. The increase in gold from deep mines was 11 per cent. The output of placer gold decreased 5 per cent.

The yield of $22,442,296 in gold in California was the largest in 33 years, or since 1883; for the fifth time in 51 years it exceeded $20,000,000; and with the exception of 1883 it was larger than it has been since 1864. It is to be noted, moreover, that the increase for 1915 was due to the deep mining operations and not to the dredge output as has been the case for several years past. The dredges maintained their large percentage of the yield of placer gold and increased the output slightly in 1915 in spite of the falling off in hydraulic, drift, and surface mines. Since gold-dredging operations commenced in California in 1898 the total output of gold from that source to the end of 1915 has been $79,104,231.

Since 1898 the Oroville (Butte County) dredging field has yielded $28,472,295 in gold, not including $1,732,620 derived in the last six years from dredges in adjacent districts in the same county. The Marysville (Yuba County) field has produced from 1903 to 1915, inclusive, $24,298,850 in gold. The Folsom (Sacramento County) field has yielded since 1902 from dredging $17,027,053. These figures do not include the many dredges operating in other localities in the State.

The output of ore from the deep mines of the State was larger in 1915 than it ever has been before, except in 1909. Moreover, the ore has improved in average value. In the Mother Lode region the principal deep mine center is at Jackson and Sutter Creek. At this camp the combined mines produced 424,922 tons of ore, averaging $5.45 in gold and 3 cents in silver, a total of $5.48 a ton. Other mines on the Lode in this county, especially at Amador City, reduced the average recovery for the whole county to $4.76 per ton. In the Grass Valley district of Nevada County (including mines at Nevada City) the average value of the ore produced in 1915 was $11.14 in gold and 7 cents in silver, a total of $11.21 a ton. At Kennett, Shasta County, where the Mammoth Copper Co.'s mines and smelter are situated, 311,459 tons of ore were treated from all the mines, which yielded $477,684 in gold, or $1.53 a ton; $396,183 in silver, or $1.27 a ton; $3,772,218 in copper, or $12.11 a ton; $1,022,722 in zinc, or $3.28 a

ton, making a total of $5,668,807, or $18.29 a ton, as compared with a total of $3,087,279, or $12.70 a ton in 1914.

The tables of 1914 showed that silver and silver-lead ores were mined for the first time in years, and purely zinc ores were shipped in for the first time in 1915. Silver produced from silver ores amounted to 51,428 fine ounces, valued at $26,074. The gold produced from silver ores amounted to 95.98 ounces, valued at $1,984. The quantity of silver-lead ores was only 144 tons and from this was obtained 17,076 ounces of silver, valued at $8,658, and 29.21 ounces of gold, valued at $604, a total of $9,262, the average value per ton being $64.32 in gold and silver. These ores also produced 57,021 pounds of lead, valued at $2,680, and the average total value was $85.27 per ton.

The average value per ton in all metals of the different classes of ore mined and treated in California in 1915 was as follows: Siliceous ore, $5.69 ($5.53 in 1914); copper ores, $13.54 ($11.90 in 1914); lead ores, $23.78 ($43.94 in 1914); silver ores, $64.36 ($83.90 in 1914); silver-lead ores, $85.27 ($29.75 in 1914); zinc ores, $84.62 (none in 1914). Of the 3,002,779 tons of ore of all classes treated 2,367,912 were siliceous, or 317,575 tons more than in 1914.

The details of mining work in the Mother Lode counties are given in the section on production by counties. A condensed statement of the record of these Mother Lode counties, including all deep mines in them, is given in the following table:

Ore treated at gold and silver mills, gold and silver recovered in bullion, concentrates produced, and value of total recovery in Mother Lode counties in California, 1915.

County.	Ore treated at gold and silver mills (short tons).	Gold and silver recovered in bullion.			Concentrates produced.				Value of total recovery.	
		Gold.	Silver (fine ounces).	Average value in gold and silver per ton of ore.	Quantity (short tons).	Gold.	Silver (fine ounces).	Average value in gold and silver per ton of concentrates.	Total.	Average per ton of ore.
Amador	819,550	$2,519,284	27,144	$3.09	17,155	$1,364,575	12,521	$79.91	$3,903,969	$4.76
Calaveras	383,808	502,125	4,742	1.31	10,316	388,843	4,824	37.93	895,818	2.33
Eldorado	21,428	63,796	418	2.99	403	35,425	540	88.58	99,707	4.65
Mariposa	48,154	331,282	2,890	6.91	847	52,109	247	61.67	384,981	7.99
Tuolumne	248,907	642,948	25,211	2.63	11,236	409,037	1,045	36.45	1,065,297	4.28
	1,521,847	4,059,435	60,405	2.69	39,957	2,249,989	19,177	56.56	6,349,772	4.17

A comparison of this table with the corresponding table for 1914 shows a total increase in ore treated for the five mother lode counties in 1915 of 278,318 tons. Every one of the counties had an increased output of ore but it was most marked in Amador County.

In the mother-lode counties in 1915 there were treated at gold and silver mills 1,521,847 tons of ore, yielding in gold and silver $6,349,772, or an average of $4.17 a ton, as compared with 1,243,529 tons in 1914, yielding $5,075,522, an average of $4.08 a ton; 1,242,343 tons treated in 1913, yielding $4,728,450 in gold and silver, or an average of $3.81 a ton; 1,299,988 tons treated in 1912, yielding $4,803,935 in gold and silver, or $3.69 a ton; and 1,377,084 tons in 1911, yielding $4,910,358 in gold and silver, or an average of $3.57 a ton. It will be noted that in the last five years there has been an annual improvement in the grade of ore treated, and in the last two years an increase in output of ore also, this being very marked in 1915. The average value of gold and silver recovered in the mills as bullion in 1915 was 7 cents more than in 1914. The average value of gold and silver in the concentrates per ton was $56.56, as compared with $44.18 in 1914. There were 39,957 tons of concentrates obtained from the 1,521,847 tons of ore worked in these counties in 1915.

The total quantity of ore treated at gold and silver mills from the deep mines of the State in 1915, was 2,286,569 tons, or 292,748 tons more than in 1914. Of the total ore milled 67 per cent came from the Mother-Lode counties in 1915. Amador, the largest producer of the Mother-Lode counties, produced 36 per cent of the total quantity of ore milled in the State in 1915, and 54 per cent of the ore milled in the Mother-Lode counties.

Crude ore sold or treated in California in 1915, in short tons.

County.	Siliceous ores.	Copper ores.	Lead ores.	Silver ores.	Silver-lead ores.	Zinc ores.	Total ore.
Amador	819,631	67					819,698
Butte	47						47
Calaveras	383,825	34,831					418,656
Del Norte							
Eldorado	21,431						21,431
Fresno	261	411					672
Humboldt		31					31
Imperial	5,545						5,545
Inyo	36,141	120	12,689			9,024	57,974
Kern	198,728			207	93		199,028
Lake, Merced, and Stanislaus	50						50
Madera	1,186	862					2,048
Mariposa	48,270	578					48,848
Modoc	303						303
Mono	5,866						5,866
Nevada	315,983						315,983
Placer	22,120	60,990					83,110
Plumas	18,994	61,023	13		7		80,037
Riverside	1,102	105	114				1,321
Sacramento							
San Bernardino	50,672	420	6	233	44	300	51,675
San Diego	14	30					44
Shasta	94,286	439,664				10,322	544,272
Sierra	80,080						80,080
Siskiyou	1,079	318					1,397
Trinity	13,282	2,350					15,632
Tuolumne	248,927	15					248,942
Yuba	89						89
	2,367,912	601,815	12,822	440	144	19,646	3,002,779
Increase or decrease	+317,575	+203,947	+12,182	−20	−16,036	+19,646	+537,294
Average value per ton in gold and silver	$5.68	$1.71	$6.85	$63.77	$64.32	$3.09	$4.89

Total yield and average value per ton in gold and silver and in all metals of ore mined and treated in California in 1915.

Ore.		Total value.		Average value per ton.	
Class.	Quantity.	In gold and silver.	In all metals.	In gold and silver.	In all metals.
	Short tons.				
Siliceous	2,367,912	$13,451,909	$13,480,111	$5.68	$5.69
Copper	601,815	1,027,786	8,147,914	1.71	13.54
Lead	12,822	87,826	304,870	6.85	23.78
Silver	440	28,057	28,320	63.77	64.36
Silver-lead	144	9,262	12,279	64.32	85.27
Zinc	19,646	60,769	1,662,534	3.09	84.62
	3,002,779	14,665,609	23,636,028	4.89	7.87

Gold and silver produced in California in 1915, by methods of treatment.

County.	Ore to gold and silver mills.			Concentrates produced.		
	Quantity.	Gold.	Silver.	Quantity.	Gold.	Silver.
	Short tons.		*Fine ounces.*	*Short tons.*		*Fine ounces.*
Amador	819,536	$2,519,028	27,120	17,155	$1,364,575	12,520
Butte	23	744	47			
Calaveras	383,808	502,125	4,742	10,316	388,843	4,825
Eldorado	21,428	63,796	418	403	35,425	541
Fresno	261	2,770	14			
Imperial	5,545	14,369	83			
Inyo	32,613	244,535	9,728	7	5,085	205
Kern	192,640	964,528	16,142	27	1,736	1,570
Lake, Merced, and Stanislaus						
Madera	1,186	10,036	65			
Mariposa	48,154	331,282	2,889	847	52,109	247
Modoc	303	7,557	205			
Mono	5,866	107,033	3,686	1	269	107
Nevada	315,974	3,350,630	45,069	3,435	77,380	1,144
Placer	27,690	108,144	6,170	327	9,457	132
Plumas	18,994	97,963	693			
Riverside	1,102	7,544	81	30	848	161
San Bernardino	1,181	4,007	51			
San Diego						
Shasta	67,088	488,774	20,844	312	16,432	140
Sierra	80,076	627,205	5,365	348	33,546	503
Siskiyou	866	27,174	732			
Trinity	13,239	104,821	2,582			
Tuolumne	248,907	642,948	25,211	11,236	409,037	1,045
Yuba	89	705	6			
	2,286,569	10,227,718	171,943	44,444	2,394,742	23,140
Average value per ton		$4.47	$0.04		$53.89	$0.26

County.	Crude ore to smelter.			Old tailings treated.		
	Quantity.	Gold.	Silver.	Quantity.	Gold.	Silver.
	Short tons.		*Fine oz.*	*Short tons.*		*Fine oz.*
Amador	148	$3,007	527	14	$256	24
Butte	24	3,866	521			
Calaveras	34,848	72,808	93,280			
Eldorado	3	227	2			
Fresno	411	883	467			
Humboldt and Imperial	31					
Inyo	23,791	60,931	241,718	1,570	7,354	576
Kern	168	1,157	8,450	6,220	10,598	63
Lake, Merced, and Stanislaus	50	750	6			
Madera	862	641	4,122			
Mariposa	694	1,366	1,144			
Modoc						
Mono						
Nevada	9	475	397			
Placer	55,420	66,583	40,609			
Plumas	61,043	9,983	36,104			
Riverside	219	2,377	2,760			
San Bernardino	48,494	407,234	126,100	2,000	4,899	101
San Diego	44	1,361	18			
Shasta	477,184	531,717	884,962			
Sierra				4	1,183	4
Siskiyou	531	10,377	968			
Trinity	2,393	9,447	2,108			
Tuolumne	35	1,736	144			
Yuba						
	706,402	1,186,929	1,445,037	9,808	24,290	768
Average value per ton		$1.68	$1.04		$2.48	$0.04

Notwithstanding the large increase in the total metallic output of California in 1915 as compared with 1914, the productive mines of the State are gradually declining in number. There were 50 less mines producing in 1915 than in 1914. In every branch of gravel or placer industry the lessened number of producers is apparent. Some changes in deep-mining operations are also in evidence. There were 40 less deep gold mines reporting product in 1915 than in 1914 and 3 less silver-lead mines; but there were 24 more producing copper mines, 4 more silver, 12 more lead, and 6 more zinc. The most marked decrease in number, that of the deep gold mines, is more apparent than real. This may be explained by the fact that in the more prominent deep-mining centers, the larger companies have acquired title to numerous smaller properties of promise and have absorbed them in their own corporations. Thus these smaller individual companies or mines are eliminated from the numerical list of producing properties. Some of these larger companies own many separate claims which for years had an identity of their own and reported their product individually. Moreover, it is no longer possible to organize mining companies in California unless there is some actual apparent basis for the investment. The laws recently enacted are stringent in this respect, and official control prevents the formation of companies such as formerly existed wherein the promoters held the majority of the capital stock without having made any investment whatever. The new laws have had the effect of preventing to a certain extent the investment of capital in embryo mining operations either good or bad, with the result that few new mines are being prospected or opened. As an example of the care now taken in the preliminary stages of new mining ventures may be cited a company recently incorporated, with an authorized capital stock of $5,000,000, which plans to develop a property, believed to contain copper deposits, that adjoins the Mammoth mine in Shasta County. This company has been permitted by the State commissioner to sell 2,000,000 of its shares to the public at par—$1 per share. In issuing the permit, however, because of the fact that the property is unproved, the commissioner, after an examination of the project by an engineer of the department, has applied restrictions providing for the orderly development of the enterprise and the careful preservation of the investors' funds. All the money, except 20 per cent allowed for selling expense, is to be deposited with the Redding National Bank under a trust agreement prepared by the commissioner. None of it can be expended except for purposes first approved by the commissioner or by a committee of competent and disinterested engineers selected by the company and approved by the commissioner. Smaller organizations, in which the necessary funds are to be contributed by stockholders on a monthly installment basis, as was once a common plan, can not always get the consent of the State commissioner to sell stock, and the statements of the organizers or promoters must be subject to proof by preliminary examination before the sale of stock will be permitted. Under these conditions it may be seen that the opening of mere "prospects" is rather difficult in California, where stock must be sold to the general public to obtain funds for development purposes.

The main feature in the mining conditions in California in 1915 was the increase in the activities of the deep gold mines; the milling

ore increased by 292,748 tons and the smelting ore by 257,270 tons. Amador County regained first place in the production of gold for the year. Forty-three copper mines reported production in 1915, the largest number in the history of the State, and the copper output was the largest since 1910. Shasta County continued to lead as a copper producer, followed by Calaveras County; but Plumas County is rapidly advancing in this respect. Large gains in lead output were made in Riverside, San Bernardino, and Kern counties. The zinc output was the largest California ever had, and plans are on foot to increase the yield materially in 1916. The influence of the system of cheap transportation of ore from mine to railroad by motor truck has made itself markedly felt in many of the counties of the State—mountain, foothill, and desert—and has made it possible to work profitably mines having no reduction plant of their own.

PRODUCTION BY COUNTIES.

AMADOR COUNTY.

There were 22 producing mines in Amador County in 1915, one less than in 1914. The quantity of ore increased by 188,705 tons and the output of gold by $812,123. The silver increased 9,454 fine ounces, and the copper decreased 1,035 pounds. The total increase in the value of all metals for the year in the county was $815,538. Amador continued to lead all other counties in the State in quantity of ore treated with 819,698 tons, exceeding the next county in rank, Shasta, by 275,426 tons, and Amador also ranked first in quantity of gold produced, replacing Nevada County, which was first in 1914. The quantity of gold produced in Amador County in 1915 was 188,378.29 fine ounces, valued at $3,894,125, which exceeded the production of Nevada County by $427,403. The value of silver was $20,409 and of copper $732. There were 6 productive placer mines in the county in 1915 and 16 deep mines.

Of the total output of ore, 67 tons of copper ore and 81 tons of siliceous ore were shipped to smelters and 819,536 tons (99.9 per cent of the total quantity) were treated in gold and silver mills. From this milling ore $2,519,028 in gold and 27,144 ounces of silver, valued at $13,750, were saved as bullion, an average value per ton of $3.07 in gold and of $0.02 in silver. From this milling ore was obtained 17,155 tons of concentrates which yielded $1,364,575 in gold, an average of $79.54 a ton, and 12,521 ounces of silver, valued at $6,348, an average of 37 cents a ton, a total average of $79.91. The extraction of gold from bullion and concentrates combined was $3,883,603, an average of $4.74 a ton, and the recovery of silver was $20,098, an average of $0.024 a ton. The value of the total yield of gold and silver from milling ore was therefore $3,903,700, an average value of $4.76 a ton. In addition there were 14 tons of old tailings treated, yielding $256 in gold and 24 ounces of silver, valued at $12, a total of $268, or an average per ton in gold of $18.28 and in silver of $0.86. The ore shipped to smelters yielded $3,007 in gold and 527 fine ounces of silver, valued at $267, in addition to the copper. The yield of the placers in the county was 351.15 fine ounces of gold, valued at $7,259, and 63 ounces of silver, valued at $32. Of the placers 4 were drift and 2 were surface sluicing mines. The decrease of gold from placers was $1,812 in 1915 as compared with 1914.

There are three important producing deep mines at or near Amador City. The Bunker Hill Consolidated Mining Co. is opened by a 2,400-foot incline shaft and is equipped with a 40-stamp mill and Frue vanners. Below this mine is a separate plant, where the sand is leached after it has been separated from the slimes The fines are concentrated and the concentrates are cyanided. The precipitates are smelted, and bullion only is shipped. At the Keystone Mines (Inc.), one of the oldest deep mines in the State, the workings consist of an incline shaft 2,690 feet deep, and 8,000 feet of drifts. In 1915 some 1,700 feet of drifts and crosscuts were completed. The mine has a 40-stamp amalgamation and concentration mill. The Original Amador Consolidated Mines Co. works its ore with stamps, Hardinge mill, and Diester tables, and has an 8-ton cyanide plant.

The Fremont Consolidated Mining Co. is the only important mine near Drytown, and has the Gover, North Gover, Loyal Lode, and Fremont claims consolidated and worked as one property. There are two incline shafts 1,550 and 2,400 feet deep, respectively. The mines are equipped with a 40-stamp amalgamation and concentration mill. The ore is crushed wet under stamps, followed by amalgamation and concentration in Frue vanners. The tailings pass on to a slimes concentrating plant and the concentrates are shipped to a smelter. The Ione Coal & Iron Co., at Ione, shipped some ore sorted from the dumps, but neither mine nor mill were operated in 1915.

The region near the towns of Jackson and Sutter Creek is the most important in deep-mine gold production in the State. At Jackson, the Argonaut has, at a vertical depth of 3,300 feet, a body of the highest grade ore ever found at such a depth in the Mother Lode section of the State. During 1915 the ore milled yielded an average gross value of $13.02 a ton, or a total of $765,509. There was a net profit of $417,772 on the operations for the year. Total production of the mine to the close of 1915 has been 792,449 tons of ore milled, yielding $6,378,008, and dividends of $1,800,000 have been paid. The Kennedy has its shaft sunk to a depth of 3,900 vertical feet—the deepest shaft in any gold mine in the United States—and the ore found at this depth is very profitable. The mine is equipped with a 100-stamp mill, and the ore, after the usual amalgamation on plates, and after concentration, is treated by the chlorination process to obtain the values from the concentrates. This company has recently acquired the old Zeila mine, at Jackson, and is reopening and developing it. The South Jackson, Valparaiso, and a few smaller properties near Jackson, are also productive. The Central Eureka, at Sutter Creek, is opened by an incline shaft 3,200 feet deep. The mine has a 40-stamp mill. The South Eureka, also at Sutter Creek, is one of the very large producers among the deep gold mines of the State. The total gross output of all the deep mines at Jackson and Sutter Creek combined, in 1915, was $2,315,345 in gold and $11,674 in silver, a total of $2,327,019, from 424,922 tons of ore. The Bay State and the Mount De Oro, at Plymouth, were small producers. The Plymouth Consolidated Gold Mines (Ltd.) is the most important property in that vicinity. The shaft is 2,496 feet deep, of which 1,520 feet are vertical, and the remainder is incline. The milling capacity is 360 tons a day with 30 stamps, 2 Hardinge mills, 2 Wilfley tables, and 20 vanners. Most of the placer mines

worked in the county are drift mines at Volcano and include the Clapboard Gulch, Garibaldi, Nat White, and Humbug Diggings. At the last mine ground sluicing has been practiced. but a mill is erected for crushing the cemented gravel.

BUTTE COUNTY.

In 1915 there were 35 mines reporting production in Butte County, or five less than in 1914. There were 47 tons of ore treated in 1915, which was 362 tons less than in 1914. The total gold output of the county was $1,545,976, a decrease of $151,144 as compared with 1914. There was an increase in silver from 6,389 ounces in 1914 to 6,771 ounces in 1915. The total value of gold and silver produced in the county in 1915 was $1,549,409, a decrease of $151,244. The 17 dredges in the county mined gold to the value of $1,491,006, which was $146,449 less than 21 dredges obtained in 1914. The number of dredges operating was 4 less than in 1914; one was burned and some of them worked out their available ground and were dismantled or moved to other fields. Only 2 hydraulic mines produced in 1915, with a yield in gold of $5,644, or $610 more than in 1914. The 5 drift mines produced $29,986 less and the 8 surface or sluicing placers, $24,232 more gold than in 1914. The total gold output from placers of all kinds was $1,541,366, as compared with $1,692,959 in 1914, a decrease of $151,593. The output of deep mines in gold was $4,610 in 1915, an increase of $449. Butte is the third in rank in output of dredge gold, being exceeded by both Yuba and Sacramento counties.

In 1915 the Oroville district proper yielded from its dredging industry $1,171,315 in gold, which was $251,092 less than in 1914. The combined dredges in the county, in the Honcut and Butte Creek fields, outside of Oroville district, yielded $319,751 in gold, as compared with $215,108 in 1914.

In 1915 the following dredging companies were operating in the Oroville field, each with one machine unless otherwise noted: El Oro, Ora Vista, Natomas Co. of California (3), Oroville Dredging (Ltd.) (2), Oro Water, Light & Power Co. (2), Pacific, Oroville Union, Viloro Syndicate (dredge burned).

The companies at Butte Creek and Honcut, outside the Oroville district, are the Honcut, Kentucky Ranch, Butte Creek Consolidated, Drexler, and Pacific.

As to the other placer operations in the county, there is some drift mining being done at Bangor, Coutolenc, Magalia, and Nimshew; some hydraulicking in a small way at Enterprise; and some sluicing near Oroville. Near Stirling City, the following placer mines are operating: Alder Creek, Butte Queen, Iron Rock Channel, Sky High, Valentine, and Wescott.

The few deep mines in the county are the Mugford Mining Co., at Chico; the Edel, at Enterprise; and the Reese, at Forbestown. The quantity of ore obtained was small, but some was of exceptionally high grade.

CALAVERAS COUNTY.

Calaveras is one of the Mother Lode counties. The number of producing mines decreased from 46 in 1914 to 38 in 1915, a loss of 8. The quantity of ore mined and milled in 1915 was 418,656 tons,

an increase of 10,910 tons over 1914. The total yield of gold in 1915 was $1,391,134, an increase of $54,259; of silver, 105,125 ounces, valued at $53,298, a decrease of 4,174 ounces; and of copper, 3,789,932 pounds, a decrease of 605,512 pounds. The total value of all metals increased by $125,759 in 1915, as compared with 1914. The value of the output of copper in the county in 1915 was $663,238, as compared with $584,594 in 1914, an increase of $78,644. In 1915 productive mines to the number of 38 reported—14 deep gold mines, 3 copper mines, 5 dredges, 13 drift, and 3 surface placers. The gold recovered by dredging was $371,667; that from drift mines, $51,961; and that from surface placers, $3,730.

The average value per ton of the 383,808 tons of milling ore treated at gold and silver mills in the county in 1915 was $2.33 in gold and silver, compared with $2.32 in 1914. The average value per ton was the lowest of the Mother Lode counties. The output of ore sold or treated in Calaveras County in 1915 was 418,656 tons, which yielded 46,622.66 fine ounces of gold, valued at $963,776; 102,847 fine ounces of silver, valued at $52,143; and 3,789,932 pounds of copper, valued at $663,238. The placer output was 20,673.44 fine ounces of gold, valued at $427,358, and 2,278 fine ounces of silver, valued at $1,155. The output of the county in 1915, in gold, silver, and copper was valued at $2,107,670.

There were 383,808 tons of ore treated at gold and silver mills, from which was obtained $502,125 in gold in bullion, or $1.31 a ton, and 4,742 fine ounces of silver, valued at $2,404. The total saving in bullion was valued at $504,529, or $1.31 a ton. From the 383,808 tons of ore were obtained 10,316 tons of concentrates yielding $388,843 in gold and 4,824 fine ounces of silver, valued at $2,446, an average of $37.69 in gold and $0.24 in silver, or a total average of $37.93 per ton. The milling ore yielded $890,968 in gold; the average recovery per ton in gold was $2.32 and in silver it was $0.01; the total gold and silver recovery was, therefore, $2.33 a ton. There were 34,848 tons of smelting ore sold or treated yielding $72,808 in gold, and 93,280 fine ounces of silver, valued at $47,293, or an average value per ton of $2.09 in gold and $1.36 in silver, or $3.45 a ton in gold and silver; and 3,789,932 pounds of copper, valued at $663,238. The total value of the smelting ore was $783,339, or $22.48 a ton.

For many years Angels has been the most productive deep-mine camp of Calaveras County, but in 1915 it fell back to third place. The metallic output of Campo Seco in 1915 was more than double that of Angels, and that from Melones nearly doubled it. There are now very few producing gold mines at Angels, and they do not yield as much as in former years. The Utica Mining Co. continues to be the most important. In addition to the Utica mine, it operates the Stickle and Gold Cliff mines. The properties are opened by a vertical shaft and winze 2,700 feet deep and an incline shaft of 1,800 feet in depth. At the 100-stamp mill the ore passes through an amalgamation and concentration process and the concentrates are shipped to a smelter for treatment. At the Angels mine the work during 1915 was more that of preparation than of production, although there was some yield. The largest producer in the county is the Penn Mining Co., of Campo Seco, where a 200-ton copper smelter is operated, the matte being shipped to New York. At Carson Hill the Carson-California Mining Co. is operating a 10-stamp amalgamation and concen-

tration mill. At the plant of the Calaveras Copper Co., Copperopolis, some important change were made during the year by the installment of a 250-ton oil flotation mill. The copper ore is treated at a plant having an Allis Chalmers ball mill, classifiers, Oliver filter, and Dorr thickener. The high-grade ore goes direct to the smelter, the low-grade ore is treated at the flotation plant, and the concentrates are shipped to a smelter. This was formerly the old Union mine and there is a 1,000-foot incline shaft and a 240-foot incline shaft. There are also five other shafts from 300 to 800 feet deep which have been abandoned for years. During the year 2,980 feet of development work was done.

The most productive gold mine in the county is that of the Melones Mining Co., at Melones, where there is an 8 by 8 tunnel 5,000 feet long and an incline shaft 1,200 feet deep. The drifts, crosscuts, raises, and winzes in the mine are extensive. The amalgamating and concentrating mill has 100 stamps. There is a 350-ton sand cyanide plant, a 200-ton decantation slime cyanide plant, and a 25-ton concentrate cyanide plant. A 200-ton slime plant was added during 1915. At Milton the most important mine is the copper property of the Napoleon Mining Co., which has a 50-ton concentration mill. The treatment process is that of the jig concentration and flotation, the plant for the latter having been erected by lessees who are working ore from the old dumps. At Mokelumne Hill is the Wide Awake and Sunnyside mine. At Railroad Flat the Comet, Josephine, and Wolverine are small producers. At West Point the productive deep mines are the Deer Foot, Lightning Rod, Levaggi, and Union Development Co. The last-named mine has a Lane slow-speed mill, amalgamation on outside plates, with no concentration; tailings are impounded. The principal productive placers of Calaveras County are at Comanche and Jenny Lind, where the gold dredges are in operation. The total dredge output in gold at these two places in 1915 was $371,667. There was a production of $35,585 of gold from the following drift mines at Mokelumne Hill: Clover Leaf, Duryea, Eclipse, Stockton Ridge, and What Cheer. There were also productive placers at Angels, Mountain Ranch, North Branch, Railroad Flat, San Andreas, Sheep Ranch, Vallecita, and Valley Springs.

DEL NORTE AND HUMBOLDT COUNTIES.

There are only four productive placer mines in Del Norte County, all at Crescent City. These are the French Creek, Craigs Creek, Myrtle Creek, and Whitney & Allen, the combined output of which was $1,018 in gold and $6 in silver in 1915. No deep mines were operated.

There is only one deep mine in Humboldt County, a copper property which shipped a small quantity of ore in 1915. The placer mines of the county are mainly at and in the vicinity of Orleans, where the following were productive in 1915: California Mining Syndicate, Little Klondike, Reynolds Creek, Rocky Point, Rosalino, Rough & Ready, Salstrom, and Ten Eyck. These are all hydraulic mines. The Clover Flat, at Blocksburg, and the Weitchpec Bar, at Weitchpec, were operated as hydraulic mines. The total output of the county in 1915 was $15,947 in gold, 122 ounces of silver, and 6,468 pounds of copper, valued at $1,132, a total value of $17,141.

ELDORADO COUNTY.

Eldorado, which is one of the five Mother Lode counties, in 1915 produced 19,412.31 fine ounces of gold, valued at $401,288, and 2,669 fine ounces of silver, valued at $1,353, a total of $402,641. There was an increase of 2,943 tons of ore treated, and an increase of $267,402 in gold and of 1,486 ounces of silver. The increase in total value of metallic output of the county in 1915, as compared with 1914, was $268,101. The ore treated at gold and silver mills, amounting to 21,428 tons, yielded in bullion $63,796 in gold, or an average of $2.98 a ton, and 418 ounces of silver, valued at $212, or an average of $0.01, the total recovery in bullion being valued at $64,008, or an average per ton of $2.99 in gold and silver. There were 403 tons of concentrates derived from the milling ore, which yielded $35,425 in gold and 540 ounces of silver, valued at $274, a total value of $35,699, or $88.58 a ton in gold and silver. The milling ore yielded, therefore, in bullion and from concentrates, a total of $99,221 in gold, or an average of $4.63 a ton, and silver valued at $486, or $0.02 a ton, a total value of gold and silver of $99,707, or $4.65 a ton.

The placer mines of the county yielded 14,601.51 fine ounces of gold, valued at $301,840, and 1,708 ounces of silver, valued at $866. Of this placer gold $278,966 came from dredges, $14,236 from drift mines, and $8,638 from surface placers. There were 26 producing mines in the county, of which 17 were placers and 9 were deep mines.

Other than one dredging enterprise, there are no productive mines of much importance in Eldorado County, and there is very little new development going on in the new or the older mines. Of the deep mines working productively, the Jones claims at Diamond Springs, may be mentioned where a small stamp mill is operated. The high-grade ore from this property is hand-mortared and panned and the ore around the pockets and mortar tails is milled. It is really due to this one mine that the average value of the ore in Eldorado County, in the table in output of Mother Lode mines, stands so high, as high values for small quantities of ore are obtained. At the Shaw mine, Eldorado, there are three 10-foot Lane mills and one concentrator. There was some output at this mine, but the work in 1915 was principally development and testing. Another mine which helped to raise the average value per ton of Eldorado County ores in 1915 was the Frog Pond, at Garden Valley, where the high-grade decomposed quartz was worked in a hand mortar, and the rest of the ore shipped to a smelter. The C. A. Brown mine, at Georgetown, also handled a small quantity of high-grade ore. Other deep-mine producers at Georgetown were the Morning Star and Lincoln. The Guildford Mining Co., at Placerville, was the most important deep-mine gold producer in the county. The mine is equipped with a 15-stamp mill, 3 Wilfley concentrators, and 2 Frue vanners. The Placerville Mining Co., at Placerville, has a 5-stamp amalgamation and concentration mill, and has been operated under lease. The productive placers were the Pacific Gold Dredging Co.; Manhattan, at Garden Valley; Gold Bug, Otter Creek, and Noble, at Georgetown; Grizzly Flat, at Grizzly Flat; Burger, Coffin & Reed, Chili Ravine, Hosking, and Rising Hope, at Placerville; Deadman Flat, at Rescue; Dividend, at Shingle; and Fort Jim, at Smith Flat. There were also some small placer mines at Josephine and Omo Ranch.

INYO COUNTY.

There were 35 productive mines in Inyo County in 1915, all deep mines, or 9 more than in 1914. Of these mines 12 were gold, 3 copper, 18 lead, and 2 zinc. The total value of the output for 1915 was $1,254,110, which is $507,552 more than in 1914. The value of gold was $317,905, or $52,171 more than in 1914. The silver amounted to 252,257 ounces, valued at $127,894, which made this county rank second to Shasta in yield of silver. The decrease in output of silver in 1915 was 214,318 fine ounces, as compared with 1914, or $130,122 in value. The output of copper in 1915 was 151,768 pounds, valued at $26,559, a decrease in quantity of 141,044 pounds and in value of $12,385. The lead output was 4,347,967 pounds, valued at $204,355, as compared with 4,205,154 pounds, valued at $164,001 in 1914, an increase in quantity of 142,813 pounds and in value of $40,354. The production of zinc in 1915 was 4,656,427 pounds, valued at $577,397, an increase in quantity of 4,266,956 pounds, and in value of $557,534, as compared with 1914.

There were treated in 1915 in Inyo County, 57,974 short tons of ore, of which 36,141 tons were siliceous ore, 120 tons copper ore, 12,689 tons lead ore, and 9,024 tons zinc ore. The deep mines in 1915 yielded 15,378.66 fine ounces of gold, valued at $317,905, and 252,257 fine ounces of silver, valued at $127,894. Of the gold, 14,142.82 fine ounces, valued at $292,358, were obtained from siliceous ore; from copper ores were obtained 4.02 fine ounces, valued at $83; from lead ores, 1,104.84 fine ounces, valued at $22,839; and from zinc ores, 126.98 fine ounces, valued at $2,625. The production of silver from siliceous ore was 6,277 fine ounces, valued at $3,182; from copper ores, 6,400 fine ounces, valued at $3,245; from lead ores, 125,292 fine ounces, valued at $63,523; and from zinc ores, 114,288 fine ounces, valued at $57,944. The siliceous ore, therefore, yielded $295,540 in gold and silver, the copper ores, $3,328; the lead ores, $86,362, and the zinc ores, $60,569, a total of $445,799 in gold and silver for the county.

The most important producer in Ingo County was the Cerro Gordo Mining Co., near Keeler, which is a lead-zinc mine, yielding gold, silver, copper, lead, and zinc, the principal value being zinc.

The property is opened by a vertical shaft 700 feet deep and numerous drifts and adits. There is no reduction plant, the lead-silver ore being shipped to the United States Smelting Co., at Midvale, Utah, and the zinc ore to the Kansas plants of the same company. The company recently completed and put in operation an aerial tramway from the mine to the railroad station. This was built on the A. Leschen heavy-duty friction type, in two sections, the total length being 29,118 feet, or between 5½ and 6 miles. There is a difference of 5,000 feet in the elevations between terminals. In the first or upper section there is a 20-horsepower surplus of power developed in this gravity tramway, which is utilized for operating an air compressor. The next property in importance is that of the Tecopa Consolidated Mining Co., at Tecopa, which also produces gold, silver, copper, lead, and zinc, the largest value being in lead. The most productive gold mine in the county is that of the Skidoo Mines Co., at Skidoo, where there are three 5-stamp batteries and the ore is treated by amalgamation and cyanidation. Another gold

mine, almost as important, is the Keane Wonder, near the border of Nevada. At Ballarat the operators of the Cashier mine ceased work and closed the mine in September, 1915, but some production had been made. At the same place the Gem group, Tecopa Chief, and Blue Reef mines were small producers. The productive mines at Big Pine were the Fish Springs Hill and Blue Jay; and the Bishop Creek Milling Co., at Bishop, yielded considerable gold. Among the producers at Darwin are the Christmas Gift, Lane, Darwin Development Corporation, and Yucca. In addition to the Cerro Gordo mine near Keeler are the Domingo, San Lucas, Spear, Royal, and Ygnacio. The Smuggler, at Death Valley, Black Eagle and Minetta, at Independence, and Nellie H., at Lone Pine, were small producers. The productive mines at Tecopa, in addition to the Tecopa Consolidated, already mentioned, were the Ore Gulch, Spectacular, Silver Rule, and Silver Bell mines. The mines reporting product from Zabriskie and vicinity are the Carbonate, Arcturus, Fraser, and Rob Roy (of the Ibex Spring Mining Co.). A new lead mine near Trona, called the Ophir, became productive in 1915.

KERN COUNTY.

Of the 29 mines reporting production in Kern County in 1915 only 2 were placers. The total value of the metallic output of the county increased very materially, being $999,146 in 1915, as compared with $602,598 in 1914, an increase of $396,548. The total production of gold in the county in 1915 was 47,568.06 fine ounces, valued at $983,319, as compared with 28,751.05 fine ounces, valued at $594,337, in 1914, an increase in quantity of 18,817.01 ounces and in value of $388,982. The silver output in 1915 was 26,265 ounces, valued at $13,316, as compared with 14,470 ounces, valued at $8,002, in 1914, an increase for the year of 11,795 in quantity and $5,314 in value. There was no copper output in 1914, but in 1915 there was 1,571 pounds produced, valued at $275. The lead yield was 47,574 pounds, valued at $2,236, in 1915, as compared with 6,641 pounds, valued at $259, in 1914, an increase for the year of 40,933 pounds in quantity and of $1,977 in value.

There were treated 198,728 tons of siliceous ore in 1915, of which 192,440 tons were treated at gold and silver mills and 168 tons were sent to smelters. There were also 6,220 tons of old tailings treated. The yield in bullion from the ore treated at gold and silver mills was $964,528 in gold, an average of $5.01 a ton, and 16,142 fine ounces of silver, valued at $8,184, a total bullion value of $972,712 in gold and silver, and an average value per ton of $5.05. From this ore were derived 27 tons of concentrates yielding $1,736 in gold and 1,570 fine ounces of silver, valued at $796, a total value of $2,532 in gold and silver, and an average value per ton of $93.77. The 168 tons sent to the smelters yielded $1,157 in gold and 8,450 fine ounces of silver, valued at $4,284, a total value of $5,441 in gold and silver, or an average of $32.38 a ton in gold and silver. The total yield of the county in gold and silver from the deep mines was $991,315, an average of $4.98 a ton of ore treated. Two placers yielded 256.39 fine ounces of gold, valued at $5,300, and 40 fine ounces of silver, valued at $20; one was a drift mine and the other a surface placer.

The most productive gold-mining field in this county was, as usual, Randsburg [1] (which includes Johannesburg). In 1915 the mines of the district produced 184,652 tons of ore, which yielded $804,053 in gold; silver valued at $7,045; 1,571 pounds of copper, valued at $275; and 47,574 pounds of lead, valued at $2,236, a total value of $813,609. The total value in 1914 was $445,264, so that the increase for the camps in 1915 was $368,345. The quantity of ore increased 29,560 tons in 1915. The Shipsey, the Stanford Mining & Reduction Co., and a few smaller properties were operating at Johannesburg. At Randsburg the Consolidated Mines Co. has a 5-stamp amalgamation mill. The Santa Ana, Josephine, Lucky Star, Margenetta, Pay Day, and Windy are other producers. The Sunshine is worked under lease. The largest producer at Randsburg—and in southern California—is the Yellow Aster, which has a 100-stamp amalgamation mill, as well as one of 30-stamps, but the latter was not operated in 1915. An electric hoist with 2-ton skips was installed in 1915. At Caliente production was made from the Gold Peak and the Elliott. At Isabella the producers were the Caldwell, Early Sunrise, Mammoth, and Keyes mines; at Loraine, the Zenda; and at Mohave, the Mohave Consolidated. The Jeanette and Gwin were the producers at Piute; the Tropico, at Rosemond, where there is a 30-stamp amalgamation mill and cyanide plant. The Blue Mountain was operated productively at White River.

MADERA COUNTY.

This county produced a total of $40,028 in metals in 1915, as compared with $4,542 in 1914, an increase for the year of $35,486. There were 2,048 tons of ore worked, yielding $10,677 in gold; 4,187 ounces of silver, valued at $2,123; and 152,502 pounds of copper, valued at $26,688. There was also $537 in gold and $3 in silver from small placers at Coarsegold. The Texas Flat Co., at Coarsegold, has a 20-stamp amalgamation and concentration mill, and a cyanide plant is to be installed. The Daulton is a copper mine at Daulton. The Fresno Enterprise and Golden Heel are small producers at Grub Gulch. The Buchanan, Copper Queen, and Madera County Co. are copper mines near Raymond.

MARIPOSA COUNTY.

Mariposa, one of the Mother Lode counties, showed an increase in its metallic output in 1915 as compared with 1914, the gain being $256,853 in value. The total output in 1915 was $411,630; in 1914 it was $154,777. There were 16 mines operating in 1915, of which 14 were deep mines. The output of ore increased by 34,129 tons. The output of gold was $385,577 in 1915, as compared with $131,458 in 1914, an increase of $254,119. The silver output increased by 3,066 ounces and the copper yield decreased by 33,796 pounds.

The deep mines produced 48,848 tons of ore, of which 694 tons went to the smelter. The 48,154 tons of ore that went to the gold and silver mills yielded $331,282 in gold as bullion, averaging $6.88 a ton, and 2,890 ounces of silver, valued at $1,465, the total gold

[1] Hess, F. L., Gold mining in the Randsburg quadrangle, Cal.: U. S. Geol. Survey Bull. 430, pp. 23–47, 1910.

and silver value of the bullion being $332,747, or an average per ton of $6.91. From this ore were also derived 847 tons of concentrates, which yielded $52,109 in gold and 247 ounces of silver, valued at $125, a total of $52,234. The concentrates, therefore, yielded $61.52 a ton in gold and $0.15 in silver, an average yield per ton of $61.67 in both gold and silver. The 694 tons of ore shipped to the smelter yielded $1,366 in gold, 1,144 ounces of silver, valued at $580, and 136,445 pounds of copper, valued at $23,878, an average value per ton for gold, silver, and copper of $37.21. The siliceous ore yielded on the plates and from the concentrates a total value of $384,981 in gold and silver, an average total value per ton of $7.99.

The most productive mine in the county is the Mountain King, at Mountain King, where the operators did considerable development work during the year, erected a new 30-stamp mill, and put in a new 350-horsepower hydroelectric power plant. The company is on a dividend-paying basis. The next mine of importance in the county is the Original, at El Portal, which operated its 10-stamp amalgamation and concentration mill all the year. The Green Mountain Copper Co. operated in a small way at Ben Hur, as did the Bondurant at Coulterville, where the 10-stamp mill was only operated a short time. The White Gulch Mining Co., at the same place, has a 10-stamp amalgamation mill. At Hornitos, the Ruth Pearce is the principal mine. At Mariposa the Colorado and the Weston-Judkins Co. are productive, the latter having a 10-stamp mill with concentrators and canvas plant. The Mariposa Commercial & Mining Co., at Mount Bullion, made considerable output, entirely through lessees, no development or active work being done by the company itself. Near Raymond the Pearce & Pearce and the Green Mountain Copper Co. were both productive in 1915. A few small placer mines, at Jerseydale and Kinsley, made a small output.

MONO COUNTY.

The total value of the metal output in Mono County in 1914 was $16,417, according to returns received, whereas it was $109,225 in 1915, an increase of $92,808. The increase in gold was $100,481. The output of silver was 16,436 fine ounces, valued at $9,089 in 1914, whereas it was 3,793 ounces, valued at $1,923, in 1915, a decrease for the year of 12,643 ounces in quantity and of $7,166 in value. There was also 3,812 pounds of copper, valued at $507, in 1914, but none was reported in 1915.

There were 5,866 tons of crude ore treated at the gold and silver mills, yielding $107,033 in gold and 3,686 fine ounces of silver, valued at $1,869, a total of $108,902, and an average value of $18.56 per ton in gold and silver. One ton of concentrates was produced, yielding $269 in gold and 107 ounces of silver, valued at $54, or a total of $323 in gold and silver. The total value for the 5,866 tons of ore was therefore $109,225 in gold and silver, or an average value of $18.62 per ton. No ore was sent to the smelter.

There are very few productive mines in the county. They are the Casa Diablo, at Bishop; New Bodie and Standard-Midnight, at Bodie; Don Alvarado, at Mono Lake; and Pittsburg-Liberty and Serita, at Masonic, all deep mines.

NEVADA COUNTY.

Nevada County was the leading producer of gold in 1914, but it yielded first place in 1915 to Amador County, which exceeded it in output of gold by $427,403. However, it is one of the two counties of the State which in 1915 exceeded the three-million mark in yield of gold, its output having been $3,466,722. The production of gold from the deep mines increased $370,531 in 1915 as compared with 1914, but the placer gold output fell off materially. The average value per ton of ore treated in gold and silver in this county was the highest in the State—$10.91 per ton.

The quantity of ore treated in the county in 1915 was 315,983 short tons. There were 27 productive mines, of which 23 were deep gold mines and 4 were placers. The hydraulic mines produced in gold $4,272, the drift mines $31,465, and the surface placers $2,500, a total value of $38,237 from the placers. The deep mines produced 165,852.96 fine ounces of gold, valued at $3,428,485, and 46,610 fine ounces of silver, valued at $23,631, a total value of $3,452,116.

There were 315,974 tons of siliceous ore treated at the gold and silver mills and 9 tons were sent to the smelter. The value of the gold in the mill bullion was $3,350,630, or $10.60 a ton, and the silver output from the same source was 45,069 fine ounces, valued at $22,850, or $0.07 a ton. The total value of the gold and silver recovered in the mill bullion was $3,373,480, an average value of $10.67 a ton. From the milling ore there were obtained 3,435 tons of concentrates, which carried $77,380 in gold, or an average of $22.53 a ton, and 1,144 fine ounces of silver, valued at $580, or an average of $0.17 a ton. The total value of the concentrates was $77,960 in gold and silver, or an average value per ton of $22.70. From the 315,974 tons of milling ore there was recovered from both bullion and concentrates $3,428,010 in gold, or an average value of $10.84 a ton, and 46,813 fine ounces of silver, valued at $23,340, or an average of $0.07 a ton. The total value of the gold and silver recovered from bullion and concentrates was $3,451,350, the average value per ton being $10.91 in gold and silver.

The principal quartz-mining district of Nevada County is that of Grass Valley, which includes the mines in both Grass Valley and Nevada City. It has been customary in these reports for some years to publish a table showing the output of this district, but this is omitted for 1915 to avoid disclosing more detail than operators are willing to have published.

The producing companies of the Grass Valley district in 1915 were the Ben Franklin, Brunswick Consolidated, Central Consolidated, Empire Mines, Golden Gate, Kenosha, North Star Mines, Union Hill Mines, Bellefontaine, Champion Mines, California-Erie, Oustamah, Pittsburg-Gold Flat, and Ziebright. The Brunswick Consolidated is developed by a vertical shaft 1,150 feet deep and an incline shaft 1,260 feet deep, connecting with drifts from 200 to 2,500 feet long. This mine has two 20-stamp amalgamation and concentration mills, one of which was installed in 1915. A new steel headframe 85 feet high was also erected. For 1915 the working costs were $6.78 per ton, to which should be added $1.81 for improvements, making a total of $8.59. The operating profit was $72,656, or $3.30 a ton.

The ore on the lower levels of the mine differs in character from the ore on the upper level in that it contains a smaller proportion of free gold and yields higher-grade concentrates. The mining costs were $4.96 a ton and the milling costs 83 cents a ton.

The Empire Mines is one of the larger producers of the district. The Golden Center has an incline shaft 900 feet in depth and 2,200 feet of development work was done in 1915. The mine is equipped with a 10-stamp amalgamation and concentration mill. The Kenosha, which is equipped with a 5-stamp mill, was operated a short time under bond. The North Star Mines has a shaft which has been sunk 6,350 feet on the dip of the vein. The production in 1915 was derived chiefly from stopes above the 3,400, 4,000, and 4,400 foot levels and was obtained from 109,860 tons of ore crushed at an aggregate cost of $5.74 per ton crushed ($5.35 per ton mined), which left a profit of $4.18 per ton crushed. The company obtained in the mills 80.37 per cent by amalgamation and 19.63 per cent by cyanidation. The value realized was about 97 per cent of the total gold and silver in the ore. Dividends amounting to $250,000 were paid during the year. This property from 1884 to the end of 1915 has mined and crushed 1,358,394 tons of ore, yielding an average of $12.84 per ton, or a total of $17,450,526. The operating and development expenses during the period have been $10,766,384, leaving a profit of $6,684,143.

The Union Hill Mines are opened by a shaft 760 feet deep, with numerous drifts. It is equipped with a 20-stamp mill. Tungsten ore of a profitable character has been discovered in the slates of the Calaveras formation on the lower levels of this mine, and is being milled, concentrated, and marketed.

The Pittsburg Gold Flat mine, at Nevada City, is opened by a 1,600-foot inclined shaft and is equipped with a 10-stamp mill. The Champion mines are owned and operated by the North Star Mines, at Grass Valley. The Republic mine is operated at Graniteville; the Consolidated St. Gothard, at North Columbia, and the Black Bear, at Rough and Ready. Among the productive deep mines at Washington are the Erie Consolidated, German, and Ocean Star. At the same place the Gaston is opened by a crosscut tunnel 4,886 feet long and laterals north and south. In the 10-stamp mill the ores are treated by amalgamation.

The few placer mines in Nevada County are at French Corral, North Bloomfield, and in the vicinity of Dutch Flat, on the Nevada County side.

PLACER COUNTY.

In 1915 Placer County produced gold and silver valued at $438,862, as compared with $601,855 in 1914, a decrease of $162,993. The decrease in output of gold in 1915 was $182,893. This decrease in gold yield is more apparent than real for the following reason: One of the larger dredges has been working on American River, along the winding center of which the boundary line between Placer and El Dorado counties passes. The dredge works part of the time in one county and part of the time in the other, and no record is kept showing the output of each county, as the dredge is back and forth so much that a record is practically impossible. Therefore, as the product of this dredge was credited entirely to Placer County in 1914, it was, for 1915, credited entirely to Eldorado County. The

total yield of gold was 20,042.68 fine ounces, valued at $414,319, and the yield of silver was 48,408 fine ounces, valued at $24,543.

The deep mines produced from 83,110 tons of ore 8,909.90 fine ounces of gold, valued at $184,184; 46,911 fine ounces of silver, valued at $23,784; and 1,979,309 pounds of copper, valued at $346,379. The total value recovered from deep mines was $554,347. The placer mine yield was 11,132.78 fine ounces of gold, valued at $230,135, and 1,497 fine ounces of silver, valued at $759, a total of $230,894. Of the placer gold, $465 was recovered from hydraulic mines, $93,812 from dredges, $120,648 from drift mines, and $15,210 from surface placer mines. The yield from placer mines was $232,265 less in 1915 than in 1914. The deep-mine increase in gold was $49,372. The total metallic output for the county in 1915 was valued at $785,241. There were 30 producing placers in the county in 1915, or 6 less than in 1914, and there were 11 productive deep mines, a total of 41. Placer continues to be the leading drift-mining county of the State. Dredges produced $202,200 less in 1915 than in 1914.

Of the deep mines of the county, the Oro Fino, at Auburn, is opened by a 327-foot shaft and is equipped with a 10-stamp amalgamation and concentration mill, completed and put into operation in October, 1915. The Banner is a small producer at the same place. The Reno Consolidated, Mitchell, and Spanish Mines Consolidated are small producers near Forest Hill. The most important producer in the county is the Dairy Farm mine of the Vantrent Mining Co., near Lincoln. This is a copper property, but produces gold and silver also. Operators ceased treating the oxidized ore by cyanidation early in the year and dismantled the cyanide plant. All the copper sulphide ore is now shipped to the smelter at Tacoma, Wash. During the year a sorting plant was installed and a narrow-gage railroad, 8½ miles in length, was completed. At Newcastle are the Big Bursar and the Spanish Hill mines, the latter being a new property with no reduction works but leasing the 10-stamp mill of the Big Bursar Co. The Pioneer, at Towle, is an important producer, which is opened by 2 adits, 3,000 and 1,600 feet long, respectively. The reduction equipment is a 20-stamp amalgamation and concentration mill and a small cyanide plant for treating the concentrates. The Helester is operating in a small way at the same place, as is the Herman at Westville.

Three dredge companies operated in Placer County in 1915. The Gaylord, dredging on bars in American River, after some production, closed down permanently during the year. The Eldorado & Placer Counties Co. worked throughout the year on the Middle Fork of American River. The Lincoln dredge worked on Quartz Flat (or Gold Hill), beginning operations in April, 1915. Most of the other placer producers of the county are drift mines, such as the Haub, at Blue Canyon; Acacia Gravel, at Bullion (operating the Damascus Gold property under lease); Christmas Hill, at Butchers Ranch; Federal Drift and Union Placers, at Dutch Flat. At and near this old hydraulic mining town more or less gold is obtained on American River by "snipers," who work through short boxes or rockers. The gold all comes from ground that has been washed into the river from the old hydraulic mines worked 30 to 50 years ago. At Forest Hill are the Gavin, Dardanelles, Excelsior, and

Paragon (in Volcano Canyon), all drift mines. The Indian Hill and Washington drift mines are at Gold Run. At Iowa Hill are the Dayton, Gleason, McGeachin Placer Co., and Penn Valley, all drift mines. At Last Chance are the Frankmont, Pacific Slab Consolidated, and Pine Nut (or Lincoln). The drift mines near Loomis are the Sequel and Pendleton; the Sierra Nevada is at Michigan Bluff; and the Euchre Bar and Sunset claims are near Towle.

PLUMAS COUNTY.

The total yield from Plumas County in 1915 was $548,518 more in values than in 1914. This was almost entirely due to the great increase in the production of copper, although the gold and silver increased materially. The quantity of ore treated increased fourfold.

The production of gold from deep mines was 5,221.89 fine ounces, valued at $107,946; the production of silver was 37,097 fine ounces, valued at $18,808; the copper was 3,122,503 pounds, valued at $546,438; and the lead was 4,256 pounds, valued at $200. There were 18,994 tons of siliceous ore treated at gold and silver mills, which yielded $97,963 in gold and 693 fine ounces of silver, valued at $351, an average value of $5.18 a ton in gold and silver. The crude ore treated at the mills yielded no concentrates. The 61,043 tons sent to the smelter yielded $9,983 in gold and 36,404 fine ounces of silver, valued at $18,457; in addition 3,122,503 pounds of copper were produced, valued at $546,438, and 4,256 pounds of lead, valued at $200, a total value of $575,078, or an average per ton of $9.42. There were 12 producing placers and 15 producing deep mines. Of the placers, 5 hydraulic mines produced $29,698; 3 drift mines, $8,247, and 4 surface placer mines $21,549—a total of $59,494. The hydraulic mines increased by 1, the drift mines decreased by 1, and the surface placers decreased by 11 in 1915, as compared with 1914. There was a marked decrease in value of the production from all classes of placer mines.

Of the Plumas County deep producers by far the most important was the Engels Copper Co., at Taylorsville, copper being now the predominant metal and far exceeding the gold in value. At the Engels the 200-ton oil flotation plant was doubled in capacity in December, 1915, and the concentrates were shipped to the Garfield smelter at Salt Lake City. The mine has a smelting furnace, the use of which was prohibited by the Forest Service before it was ever started. During 1915, a 38-mile power line was constructed by the Great Western Power Co. to these mines. The Round Lake Gold Mining Co., at Blairsden, is a new and important gold producer in the county. At Clio are the Eldorado group and the Last Chance mines. The Harris, W. O. P. Co., and the Murdock (copper) mines are at Chilcoot; the Plumas Amalgamated is at Crescent Mills; the B. & M. Mining Co. is at Taylorsville; and the Southern Eureka is at Greenville. The Jamison Mining Co's. 20-stamp amalgamation mill, at Johnsville, had to close down for four months in 1915 owing to shortage of water for power purposes. At Quincy the most important mine is the Crown Point group, which is equipped with a 10-stamp mill. At the same place the Oro Fino is a small producer; and the Seneca Consolidated Mining Co. is operating at Seneca.

The producing placers are the small hydraulic mines at Belden; Great Divide (drift), at Crescent Mills; Bellevue drift and Consolidated Alturas, at La Porte; Gold Mountain hydraulic and New York, at Meadow Valley; Spring Garden drift and small hydraulic claims, at Quincy; and the Standard, at Sloat.

RIVERSIDE AND SAN DIEGO COUNTIES.

The output of ore in Riverside County was 1,321 tons, which yielded $10,769 in gold and 3,002 fine ounces of silver, valued at $1,522, with 20,772 pounds of copper, valued at $3,635, and 116,021 pounds of lead, valued at $5,453, or a total value of $21,379, which is $10,057 more than the total value in 1914. The Snowstorm mine is near Banning. The New Eldorado, at Indio, has a 5-stamp amalgamating and concentrating mill, which was operated for nine months of the year. The Santa Rosa and the Justice were the producers at Perris. The Bendigo Mines Co. now owns the Jack Knife group at Vidal. The Calzona Mines Co., at the same place, ships its copper ore to the smelter at Hayden, Ariz. The company put up a new gasoline hoist during the year, and considerable development work was accomplished.

From San Diego County a small quantity of copper ore came from the Encinitas Copper Mining & Smelting Co., of Encinitas, and a few tons of gold ore from the Fraction mine, at Julian. The total value was $1,898. No mines reported output from this county in 1914.

SACRAMENTO COUNTY.

Sacramento is fourth in rank of the four counties in California that produced more than $2,000,000 in gold in 1915. The total output of gold in 1915 was $2,131,813, which is $32,678 less than in 1914. The output of silver decreased by 80 ounces. The total value of the yield of gold and silver was $2,134,964, which is $33,008 less than in 1914. Practically the entire gold output of the county was produced from dredging operations, no deep mines and only a few small placer mines being operated. There were 11 dredges in operation in 1915, of which 9 were owned by the Natomas Co., of California, and the others by the Wilkesbarre Dredging Co. and the Indiana Gold Dredging Co. The output of gold by the dredges in the county in 1915 was $2,129,781 or $31,872 less than in 1914. During 1915 the Natomas Co. recovered with the gold 180 ounces of platinum, valued at $7,142.

SAN BERNARDINO COUNTY.

There was a general increase in the quantity and value of the metals produced in San Bernardino County in 1915 as compared with 1914, the total increase in value being $252,266. The greatest increase was in gold and amounted to $207,495. Thirty-four producing mines were reported in 1915, an increase of 9 over 1914. Silver increased 58,821 fine ounces; copper, 45,210 pounds; lead, 23,914 pounds; and zinc, 39,847 pounds. The gold output was 20,170.78 fine ounces, valued at $416,967.

The silver produced in the county in 1915 was 126,558 fine ounces, valued at $64,165; copper, 135,030 pounds, valued at $23,630; lead, 63,427 pounds, valued at $2,981, and zinc, 39,847 pounds, valued at

$4,941. Thirteen gold mines, 7 copper mines, 9 silver mines, 1 silver-lead mine, 1 lead mine, 2 zinc mines, and 1 placer reported production in 1915. There were 50,672 tons of siliceous ore sold or treated in the county in 1915, 420 tons of copper ore, 6 tons of lead ore, 233 tons of silver ore, 44 tons of silver-lead ore, and 300 tons of zinc ore, a total of 51,675 tons. Of this total quantity 1,181 tons were treated at gold and silver mills and yielded $4,007 in gold and 51 fine ounces of silver, valued at $26. No concentrates were produced from this ore. There were 48,494 tons of crude ore sent to smelters that yielded $407,234 in gold and 126,400 fine ounces of silver, valued at $64,085. In addition, 2,000 tons of old tailings were treated, which yielded $4,899 in gold and 101 fine ounces of silver, valued at $51. The copper ores produced 76.38 fine ounces of gold and 6,460 fine ounces of silver, valued at $3,275. The lead ores produced 5.42 fine ounces of gold and 61 fine ounces of silver. The silver ores yielded 76 fine ounces of gold and 46,493 fine ounces of silver; the silver-lead ores, 4.01 fine ounces of gold and 9,816 fine ounces of silver; and the zinc ores, 394 fine ounces of silver.

The most important productive mines in the county in 1915 were the Bagdad and Roosevelt, owned by the Pacific Mines Corporation, at Stagg. During the year they developed additional ore on the lower levels and centralized the different shafts. The ore was all shipped to a smelter, but a 100-ton cyanide plant was being installed. The next mine of importance in output was the United Greenwater, at Amboy, a gold-producing mine. The Bagdad Chase Co., at Barstow, worked old tailings only. The Vanderbilt, at Barnwell, and the Death Valley Arcalvada, Mescal, Piute, and Pioneer, at Cima, were small producers. Some silver came from the old mines at Daggett, and some also from the Bonanza King, at Goffs. The Lucy Gray, at Desert, Maricopa Queen, at Milligan, and Desert King, at Needles, were also small producers. The Emperor, near Nipton, shipped copper ore. The Crescent, at the same place, is a silver mine, and zinc ore was shipped by D. R. Oliver from Oro Grande. The Kane, Kelton & Horn mine shipped a small quantity of copper to the Copper Queen smelter at Douglas, Ariz. The Sunnyside, in the Monumental district, shipped copper ore to the plant at Hayden, Ariz. Shippers from Silver Lake were Brauer & Sons, Riggs Mining Co. (silver), and McCaskell (silver). The Silver Bell, at Trona, was a small producer, as were the Rose Lease and the Moore, at Victorville. From Vidal copper ore was shipped by the Arnold, Grennel, and Hawkeye mines. The Rob Roy and the Ibex Spring Mining Co., at Zabriskie, produced lead-zinc ore. The California, at Yermo (formerly the Alvord Consolidated), has a Nissen mill of six 1,400-pound stamps, using plain amalgamation. There was one small productive placer near Barstow.

SHASTA COUNTY.

The metallic output of Shasta County in 1915 reached a total value of $8,009,609, the highest since 1909. The increase for 1915, as compared with 1914, was $3,210,278. The number of producing mines in the county in 1915 was 31, the same as in 1914. The total number of tons of ore sold or treated was 544,272, an increase of 108,061 tons. The production of gold was valued at $1,120,848, an increase of $19,646. The yield of silver was 906,441 ounces, valued at $459,566

an increase in quantity of 279,487 ounces and in value of $112,860. The output of copper of the county in 1915 was 30,787,846 pounds, valued at $5,387,873, an increase of 5,589,177 pounds in quantity and of $2,036,450 in value, as compared with 1914. The recoverable zinc was 8,397,758 pounds, valued at $1,041,322; none was reported in 1914. A small quantity of this was electrolytic zinc from an experimental plant, but the bulk of it was recovered from sorted zinc ore shipped to the United States Smelting Co.'s plant at Altoona, Kans. Shasta continues to be the leading county of the State in total value of metallic output. It also leads all other counties in quantity and value of copper, silver, and zinc. Only one smelter was in operation in the county in 1915—the Mammoth—all others being closed owing to smelter-fume litigation. Some other copper mining companies ship their ore out of the county for reduction.

The total number of deep mines from which production was reported in Shasta County was 24, as against 22 in 1914. Of these, 17 were gold mines, 5 were copper, and 2 were zinc mines. The output of 544,272 tons of ore was made up of 94,286 tons of siliceous ore, 439,664 tons of copper ore, and 10,322 tons of zinc ore. The placer mines of the county in 1915 yielded 4,059.87 fine ounces of gold, valued at $83,925. This production came from 1 hydraulic mine, 2 dredges, and 4 surface placers.

The gold from the deep mines amounted to 50,161.15 ounces, valued at $1,036,923, and the silver to 905,946 fine ounces, valued at $459,315. The gold derived from siliceous ore amounted to 35,248.30 fine ounces, valued at $728,647, and that from copper ore to 14,912.85 ounces, valued at $308,276. The production of silver from siliceous ore was 45,889 fine ounces, valued at $23,265, and from copper ore 860,057 fine ounces, valued at $436,050. The siliceous ore, therefore, yielded $751,912 in gold and silver and the copper ore $744,326 in gold and silver from the deep mines.

The gold and silver mills in Shasta County in 1915, treated 67,088 tons of ore, which yielded in gold bullion $488,774, an average of $7.29 a ton, and 20,844 fine ounces of silver, valued at $10,568, an average of $0.16 a ton. The total recovery of mill bullion was valued at $499,342, or an average value in gold and silver of $7.45 a ton. This ore produced 312 tons of concentrates, with a gold value of $16,432, and 140 fine ounces of silver, valued at $71, a total value of concentrates of $16,503. The average value per ton of concentrates was $52.67 in gold and $0.23 in silver; and the total gold and silver value from mill bullion and from concentrates was $515,845, or an average recovery of $7.69 a ton.

The crude ore sent to the smelters, amounting to 477,184 tons produced (in addition to the copper), $531,717 in gold, an average of $1.11 a ton, and 884,962 fine ounces of silver, valued at $448,676, or $0.94 a ton. The total value of gold and silver recovered from the ore sent to smelters was $980,393, or an average value of $2.05 a ton.

The most important deep mining property in Shasta County and in the State is the Mammoth Copper Co., at Kennett. The value of its total output exceeds that of the property next in rank of production by more than $3,000,000. In 1915 it had three 400-ton furnaces in operation for the entire year. The treatment process is straight pyritic smelting, with converting plant. The blister copper was shipped for refining to Chrome, N. J., and the sorted

zinc ore shipped to Altoona, Kans. During the year a zinc-sorting plant of the belt style was operated to raise the grade of mined zinc ore for shipment. The principal output of the plant is copper, but a great deal of gold and silver is also produced. The company also does a large "custom" smelting business. The Mountain Copper Co. (Ltd.) is another of the large producers of the county. The three contiguous mines operated as one group by the company are the Iron Mountain, No. 8, and Hornet. In the treatment process the sulphide ore is roasted to manufacture sulphuric acid and then the calcines, with a suitable mixture of other ores, are smelted in reverberatory furnaces. The copper matte, carrying gold and silver, is converted to blister and shipped for refining to Baltimore, Md. The ore from these mines in Shasta County is shipped by rail to the company's smelting plant near Martinez, on San Francisco Bay, the smelters at Keswick, near the mines, having been closed for some years. The Ruby Pearl mine, near Castella, is a small gold producer. The Balaklala Consolidated Copper Co., at Coram, did not treat its ores in its own plant, but shipped them to another smelter.

The company did not commence shipping until the end of August, 1915, and then continued throughout the rest of the year. The Hazel Mining Co., at French Gulch, is one of the larger gold producers of the county, and the Gladstone mine, which it operates, is opened by an adit, 3,300 feet long, to the shaft (or winze) which is underground and vertical to a depth of 1,500 feet. In 1915 the shaft was sunk from the 1,250 to the 1,500-foot level, and the 1,375-foot level was opened 1,200 feet. The mine is equipped with a 30-stamp amalgamating and concentrating mill. Other mines at French Gulch, more or less productive in 1915, are the Eldorado & Eureka group, Niagara, Summit, Summit Gulch Development Co., Washington, and the Western Exploration Co. The Uncle Sam mine, at Kennett, is opened by a 1,200-foot adit and equipped with a 10-stamp amalgamation and concentration mill; in 1915 it was worked for 11 months by lessees. The Pittsburg Mount Shasta mine, at Keswick, had a small output, but the work done was mainly exploration with a diamond drill. The Victor Power & Mining Co., at Knob, Harrison Gulch district, worked the Midas mine productively. Among other productive mines, mostly in a small way, were the Graves, at Ono, and the Greenhorn Mountain Copper, near Redding. The Evening Star, at Whitehouse, was the most productive deep gold mine in the county in 1915, its ore going to the Mammoth smelter. Quite a number of small properties supplied ores to the Mammoth smelter during the year. Of the placer mines in Shasta County there was some output at Bayles, French Gulch, and Gas Point, and one dredge operated at Larkin and another at Redding.

SIERRA COUNTY.

The total metal production for Sierra County in 1915 was valued at $729,518, as compared with $725,129 in 1914, an increase of $4,389. The deep-mine gold increased $58,289, but the placer gold decreased $54,090. There were 80,076 tons of siliceous ore treated in gold and silver mills in 1915, yielding $627,205 in gold, and 5,365 fine ounces of silver, valued at $2,720, a total of $629,925 in gold and silver, or an average of $7.86 a ton. In addition 4 tons of old tailings

were treated, yielding $1,183 in gold and 4 ounces of silver, valued at $2, a total of $1,185. The output from the placers in the county in 1914 was 3,116.70 fine ounces of gold, valued at $64,428, and 353 fine ounces of silver, valued at $179, a total of $64,607. Of this placer gold $44,177 came from hydraulic mines, $13,282 from drift mines, and $6,969 from surface placers. There were 31 productive mines in the county in 1915, of which 15 were deep gold mines. Of the 16 placers 3 were hydraulic mines, 6 were drift mines, and 7 were surface placers.

The most important producing camp of the county is at Alleghany, and the deep mines there in 1915 produced 46,704 tons of ore carrying $441,530 in gold, as compared with 45,809 tons of ore, yielding $433,917 in gold in 1914. There was very little difference either in quantity of ore or of value in gold in the two years compared, although an increase of $7,613 in gold in 1915 is shown. At this place the Croesus, operated throughout the year, has a 15-stamp amalgamation and concentration mill. The Oriental was worked only half of the year. At the Original mine, the 400-foot shaft was sunk 150 feet during the year. The Twenty-One mine is opened by a 2,000-foot adit, which was extended 100 feet in 1915. The ore is crushed in a 10-foot Lane mill. The Tightner Mines Co. operated its mine and 20-stamp mill for the entire year, and made the largest output of the mines in the county. The White Wings, at the same place, was also productive. At Downieville the deep mines producing were the Cliff Leasing Co. and the Mexican. The Four Hills Mining Co. was a large gold producer at Johnsville. The Sierra Alaska Mining Co., at Pike, is operated by a vertical shaft 680 feet deep and a winze 235 feet deep. In 1915 there were 4,967 feet of drifts and up-raises cut. The mine has a 40-stamp mill and Wilfley concentrators. At Sierra City, the Sierra Buttes Co. extended its main 4,900-foot adit by 600 feet. The mine has a 60-stamp mill and a 100-ton cyanide plant. Other productive mines at this point are the Buttes Saddle, Cleveland, Essex, and Swastika.

Of the placers of the county the most productive is the Brandy City hydraulic, at Brandy City, between Canyon, Cherokee, and Boyce creeks. At Camptonville are the Depot Hill hydraulic, Indian River drift, and Flat Iron drift mines. Those at Downieville are the Best Chance, Monte Cristo, and Wide Awake; at Forest, the Bull Moose drift; at Pike, the Mount Alta drift; at Port Wine, the Caledonia; at Sierra City, the Lady's Canyon, Last Resort, and Pig Canyon; and at Table Rock, the Bruckerman.

SISKIYOU COUNTY.

In 1915 Siskiyou County produced 20,642.39 fine ounces of gold, valued at $426,716; 4,104 ounces of silver, valued at $2,081; and 86,611 pounds of copper, valued at $15,157, a total of $443,954. This was an increase of $130,086 in 1915, as compared with 1914. There were 12 deep mines producing, as compared with 19 in 1914, a decrease of 7, and they produced 1,397 tons of ore, yielding 1,816.53 fine ounces of gold, valued at $37,551, and 1,700 fine ounces of silver, valued at $862, a total of $38,413, as compared with $45,516 in 1914. The 42 producing placers yielded 18,825.86 fine ounces of gold, valued at $389,165, and 2,404 fine ounces of silver, valued at

$1,219, a total of $390,384, as compared with $268,352 in 1914. This was an increase of $122,032 for 1915, as compared with 1914, of which $121,661 was gold. Thus the placers yielded $351,971 more in gold and silver than the deep mines. The number of producing mines (54) in Siskiyou was larger than in any other county in the State, but there were 13 mines less than in 1914. Of the placers 35 hydraulic mines produced in gold $171,377; the 2 dredges, $214,511; the 2 drift mines and 3 surface placers, $3,277. The hydraulic mines produced $19,192 more in gold in 1915 than in 1914. There are more operative hydraulic mines in Siskiyou County than in any other county of the State and their gold output is the largest. There are no Federal restrictions against hydraulic mining in Siskiyou as there are in counties in the drainage basins of Sacramento and San Joaquin rivers. The only deep-mine producer of note in the county is the Royal, at Callahan. Other deep mines at this place are the Bouvier, Pocket Dyke, and Two-and-a Half. The Monarch, at Black Bear, made a nominal output. Other deep mines producing in a small way are the Lily at Cecilville; Highland, at Etna Mills; Kennett Exploration Co. (copper), at Fort Jones; Ash Creek, at Hornbrook; Eureka and W. Y. O. D., at Rollin; and Merriam & Goodale, at Sawyer's Bar.

Of the placers of the county the largest producer is that of the El Oro Dredge Co., at Yreka, and the second in importance is the Siskiyou Dredge Co., at Fort Jones. Of the hydraulic mines, the Siskiyou Mines Co. (of New York), on the Klamath River, 6 miles from Happy Camp, which was operated for 11 months of the year, produced the most gold. Small placer producers at Black Bear are the Baines, Nugget Bar, and Mandell; and the principal placers at Callahan are the Kangaroo, Messner, and Sugar Hill. At Cecilville the hydraulic mines are the Banner, Johnson, and Sightman. The Michigan Salmon hydraulic is an important producer at Forks of Salmon, and uses a Ruble elevator. At Hamburg the hydraulic mines are the Dick Morris, Hammer, Happy Home, and Kunz Flat. The Happy Camp placers are the Davis Consolidated, Morning Star, Shady Side, Siskiyou Mines Co., Squirrel Creek, and a few smaller properties, the combined gold production of all being $51,053. The Siskiyou Klondike hydraulic is at Oak Bar, and the Frazier hydraulic is at Rollin. At Sawyer's Bar the most productive hydraulic mine is the Forks of Salmon River; other hydraulic mines are the Gold Hill, Klein, Multum in Parvo, Thomain, Wm. Burns, and a few smaller properties; the gold output of the camp in 1915 was $37,250. At Scott Bar the principal hydraulic mine was the Quartz Hill. The small hydraulic mines at Somesbar are the Blue Nose, Reynolds Creek, and Ten Eyck; and those at Walker are the Buckeye Bar and Jensen

TRINITY COUNTY.

In 1915 Trinity County produced 21,374.30 fine ounces of gold, valued at $441,846; silver, 6,844 fine ounces, valued at $3,470; and 300,787 pounds of copper, valued at $52,638—a total value for all metals of $497,954 and a decrease of $248,932, as compared with 1914. The decrease in gold was $301,666. There were 49 mines which reported production in 1914. Of these 10 were deep gold mines, and 1 a copper mine; and of the placers, 32 were hydraulic

mines, 2 dredges, 1 drift mine, and 3 surface placers, a total of 38 placer mines. The deep mines produced from 15,632 tons of ore 5,527.71 fine ounces of gold, valued at $114,268, and 4,690 fine ounces of silver, or $2,378, a total of $116,646 in gold and silver, as compared with $235,798 in 1914, a decrease of $119,152. The ore treated in 1915 was 15,632 tons, which was 12,088 tons less than in 1914. The largest proportion of ore came from the Globe Consolidated mine, at Dedrick. The 38 placers yielded 15,846.59 fine ounces of gold, valued at $327,578, and 2,154 fine ounces of silver, valued at $1,092, a total of $328,670, a decrease of $182,238 for 1915, as compared with 1914. The hydraulic mines decreased their yield for the year by $165,089 and the dredges decreased by $16,357.

The only deep mine producer of special note in Trinity County is that of the Globe Consolidated Mining Co., at Dedrick. The mine is opened by tunnels mainly and by scattered winzes and raises. The equipment consists of a 20-stamp cyanide mill of 100-ton daily capacity. The crude ore is treated by crusher, stamps, and tube mills, Dorr thickeners, agitators, and an Oliver filter, and the precipitate is sold in Salt Lake City. No amalgamating is done. Late in the year an option was granted to the Globe Leasing Co., which operated the property from October on. The Packer group at Coffee was operated in a small way. At Deadwood the Brown Bear mine ran its 10-stamp amalgamation mill part of the time, and the Amy Bach made a small output. The Oriole, at Douglas City, and Murphy & Layman, at Hayfork, produced to some extent. Some copper ore came from a mine on Eel River, in the southwest corner of the county. The mine was worked by open cut part of the year and the ore was sold to the Tacoma smelter. Other deep mines in the county that reported product were the Last Chance at Lewiston, Fairview at Minersville, Quinby at Quinby, and Five Pines and Surprise at Trinity Center.

Of the placers the most productive properties were the dredges at Lewiston and Trinity Center, the La Grange hydraulic near Weaverville, and the Trinity Consolidated hydraulic at Douglas City. The Fortune Teller hydraulic was also productive at Big Bar; the South Fork, at Burnt Ranch, the Little Klondike, at Blocksburg; the Morrison Gulch, Snow Gulch, and Strode, at Carrville; and the Gem, at Willow Creek. The placers at Coffee were the Alamo, Lower Wash, and Underground Treasure, and those at Denny were the Eagle Bird, B. & J., and Two Jacks. The Steve's Gulch hydraulic was operating at Dorleska. At Hayfork the placers producing were the Carrier Gulch, Drinkwater, Murphy & Layman, and Parlin. Those at Junction City were the Burger & Heimberger, Chapman & Fisher, Red Hill, and Valdor. At Quinby were the McAtee Bar and the New River mines. The mines near Weaverville were the Democrat Gulch, Homestake & Ellerbrook Consolidated, La Grange, Poverty Flat, and some smaller operators. The Altabert Dredging Co. acquired during the year the land holdings of the old Sykes Mining Co. near Trinity Center.

TUOLUMNE COUNTY.

In Tuolumne County in 1915 there was a decrease of six in the number of productive mines and an increase in output of quantity of ore and in value of gold and silver. The output of gold of the

county in 1915 was 51,185.74 fine ounces, valued at $1,058,103; the silver, 26,587 ounces, valued at $13,480; and the copper, 3,000 pounds, valued at $525. The total value for the year was $1,072,108, an increase of $119,298, of which $117,310 was in gold. The deep mines of the county produced 248,942 tons of ore which yielded 50,973.76 fine ounces of gold, valued at $1,053,721; 26,400 fine ounces of silver, valued at $13,385; and 3,000 pounds of copper, a total metal value from deep mines of $1,067,631, as compared with $952,810 in 1914. There were 27 producing mines in the county in 1915, of which 3 were placers, 23 deep gold mines, and 1 copper mine. The 2 hydraulic mines and 1 surface placer yielded 211.98 fine ounces of gold, valued at $4,382, and 187 fine ounces of silver, valued at $95, a total yield of $4,477.

The quantity of ore sold or treated in the county in 1915 amounted to 248,942 tons, or 26,435 tons more than in 1914. Of the 248,942 tons, 248,907 tons were treated in gold and silver mills, yielding $642,948 in gold bullion, an average value of $2.58 a ton, and 25,211 fine ounces of silver, valued at $12,782, or an average of $0.05 a ton, a total saving in mill bullion valued at $655,730, or an average of $2.63 a ton in gold and silver. From the milling ore 11,236 tons of concentrates were obtained, which yielded $409,037 in gold, an average value of $36.44 a ton, and 1,045 fine ounces of silver, valued at $530, an average of $0.04 a ton, a total of $409,567 in gold and silver, and a total average yield of $36.46 a ton in gold and silver.

The ore milled and concentrated yielded a total value of $1,051,985 in gold, an average of $4.23 a ton, and 26,256 fine ounces of silver, valued at $13,312, or $0.05 a ton. The total yield of gold and silver on the plates and from the concentrates was valued at $1,065,297, or $4.28 a ton as compared with $4.24 a ton in 1914.

In addition 35 tons of copper ore were sent to smelters and yielded $1,736 in gold, 144 fine ounces of silver, valued at $73, and 3,000 pounds of copper, valued at $525, a total value of all metals of $2,334, or an average value per ton of $66.69.

The largest output of ore treated in Tuolumne County in 1915 was from the Harvard Mine (Inc.), at Jamestown, but the largest output of gold was made by the Eagle Shawmut mine, at Shawmut. At Big Oak Flat the Gold Boy and Little Wonder made a small output, and there was some little pocket mining done at Chinese. The Bronx & Luella, at Columbia, ran its 2-stamp mill only a month. The Experimental Gulch, also at Columbia, is opened by a tunnel 2,900 feet long. This was extended during the year and ore opened by the tunnel was stoped out. The old 2-stamp mill was replaced by a 5-stamp mill. The Harvard, at Jamestown, is developed by a vertical shaft 750 feet deep and an inclined shaft 1,200 feet deep; the mine is equipped with a 60-stamp amalgamation and concentration mill. Some copper ore was shipped from the Mackey copper mine, at Jamestown. At Quartz, the Dutch-Sweeney Mining Co.'s mine is opened by an 1,800-foot vertical shaft. The mine is equipped with a 40-stamp amalgamation and concentrating mill and Hardinge mills have been installed for regrinding. The ore in 1915 came from the Dutch, Sweeney, and App mines. The Eagle Shawmut mine, at Shawmut, is opened by an adit crosscut 1,100 feet long, and incline shaft and winzes to a depth of 2,400 feet. The property is equipped with a 100-stamp mill and concentrators, and a 24-ton

chlorination plant, the concentrates being treated at the plant at the mine. This Mother Lode mine is remarkable in that 85 per cent of the gold value is obtained from the concentrates, only 15 per cent being recovered by amalgamation. From the total quantity of ore treated the gold recovery on the plates was 76 cents a ton and from the concentrates it was $4.46 a ton, a total of $5.22 a ton. From the concentrates alone treated separately by chlorination the gold recovery was $39.21 a ton.

The Sugarman and smaller mines around Sonora made a considerable gold production. The Black Oak, at Soulsbyville, is opened by an incline shaft 1,678 feet deep. The development work in 1915 amounted to 2,824 feet. The mine is equipped with a 100-ton all slime cyanide plant. The ore is crushed in solution, reground in tubes, classified, and passed through an Oliver filter. The Merrill precipitation process is used. The Draper, at the same place, has a 10-stamp amalgamation and concentration mill. Most of the year was spent in development work. The Jumper-California mine, at Stent, is opened by a 1,400-foot incline shaft and several miles of drifts and crosscuts. The work in 1915 was done entirely by lessees. The reduction plant consists of a 20-stamp amalgamation and concentration mill. The Santa Ysabel was reopened by the Nyman Consolidated Mines Co., at Stent, and new ore has been discovered. There is a 40-stamp amalgamation and concentration mill on the property, which has been repaired and put in order by the new company. The Mohican, at Tuolumne City, operated only a few months during the year. The New Providence, Star King, and Sherman are producers at the same place. The property of the United Mines Corporation was operated by lessees in 1915. At Tuttletown, the producers were the Atlas Consolidated, Norwegian, Street & Wise, and Tarantula. There are very few placer mines in the county, and these are at Columbia, Jamestown, and Sonora.

YUBA COUNTY.

Yuba County in 1915 held third place in rank of gold producers, being exceeded only by Amador and Nevada. It holds the leading position in production of placer gold, by reason of its gold-dredging activities. In 1915 the production of placer gold in Yuba County exceeded that of Sacramento County, its nearest competitor, by $571,192. The output of Yuba County in 1915 was 130,791.97 fine ounces of gold, valued at $2,703,710, and 10,363 fine ounces of silver, valued at $5,254, a total of $2,708,964, as compared with $2,806,008 in 1914, a decrease of $97,044. The dredges in 1915 produced $2,676,090, a decrease, as compared with 1914, of $79,644. There were 12 dredges in operation in the county in 1915, the same number as in 1914. Altogether there were 20 productive placers, including dredges, in operation in 1915, a decrease of 5 as compared with 1914. Aside from the dredges there were 7 surface placers and 1 hydraulic mine reporting production in 1915. There was only 1 productive deep mine.

The largest producer in the county was the Yuba Consolidated Goldfields, which operated 10 dredges in 1915. After the close of the year the company launched and put in operation the largest gold dredge in the world, the *Yuba No. 15*. The hull is 165 feet long,

68 feet wide, and 11 feet 6 inches deep. The bucket line is designed to dig to 80 feet in depth. The buckets are of 17 cubic feet capacity. The Marysville Dredging Co. operated 2 dredges 10 miles east of Marysville. Other placer mines in the county are the Bright Star, at Browns Valley, and Archimedes and Mammoth, near Marysville. There are a number of small sluicing mines at Browns Valley, Dobbin, Marysville, Smartsville, and Woodleaf.

OTHER COUNTIES.

Fresno County.—This county produced metals valued at $15,879, of which $4,151 was gold; 485 ounces of silver, valued at $246; and 65,612 pounds of copper, valued at $11,482. The deep mines were the Hart Copper Co. (Copper King), Sunnyside, and Uncle Sam. One placer mine was productive at Friant.

Imperial County.—One deep mine in this county produced a total of $14,411 in gold and silver in 1915.

Lake County.—The only producing mine in this county is a copper property, which produced gold, silver, and copper valued at $1,503.

Merced and Stanislaus counties.—There were three dredges and some small placers operating in these counties in 1915, the combined output of which was $273,685 in gold and 3,068 ounces of silver, valued at $1,555.

Modoc County.—This county produced 303 tons of siliceous ore in 1915, all of which went to gold and silver mills. There were no concentrates produced, and all values were recovered in mill bullion. The 303 tons of ore yielded $7,557 in gold, an average of $24.94 a ton in gold, and 205 ounces of silver, valued at $104, or an average of 34 cents a ton. The total yield in gold and silver was $7,661, or an average of $25.28 a ton.

GOLD, SILVER, COPPER, AND LEAD IN OREGON.

(MINES REPORT.)

By Charles G. Yale.

PRODUCTION.

GENERAL STATEMENT.

Number of mines producing in Oregon, quantity of ore sold or treated, and total gold, silver, copper, and lead produced in 1905–1915.

Year.	Number of mines producing.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	
1905	233	150,268	$1,405,235	90,636	846,815	1,610	$1,592,156
1906	279	138,274	1,366,900	79,346	415,803	.....	1,500,212
1907	206	110,698	1,129,261	86,718	554,104	.....	1,297,316
1908	239	50,684	865,076	43,602	291,377	2,138	926,737
1909	162	59,281	781,964	27,827	235,000	400	827,001
1910	180	82,132	679,488	35,978	13,861	.....	700,676
1911	176	98,558	633,407	45,221	93,136	.....	669,016
1912	210	90,945	770,041	57,081	260,429	39,317	849,886
1913	173	155,901	1,627,710	179,036	43,330	87,207	1,746,402
1914	105	124,331	1,591,461	142,552	39,248	16,436	1,676,153
1915	95	155,791	1,861,796	117,947	451,172	62,957	2,003,509
Increase or decrease, 1915	−10	+31,460	+270,335	−24,605	+411,924	+46,521	+327,356

Notwithstanding the rather notable increase in the total value of the metals produced in Oregon in the year 1915, there still continues to be a reduction in the number of productive mines. The total metal yield of the State increased in value $327,356, or 19 per cent in 1915, as compared with 1914. The quantity of ore produced increased 25 per cent; the gold increased 17 per cent; the copper increased 1,050 per cent; and the lead increased 283 per cent. There was a decrease of 17 per cent in yield of silver. The increase in the output of gold was due entirely to the deep mines, which produced $336,482 more in 1915 than in 1914. The output of placer gold, on the other hand, was slightly less than in 1914. The deep mines produced 24,620 ounces less silver in 1915 than in 1914. The total output of gold in the State in 1915 was 90,064.38 ounces, valued at $1,861,796, as compared with 76,986.92 ounces, valued at $1,591,461, in 1914. The production of silver in 1915 was 117,947 ounces, valued at $59,799, a decrease of 24,605 ounces in quantity. The output of copper increased from 39,248 pounds in 1914 to 451,172

pounds in 1915, with an increase in value of $73,735. The production of lead in 1914 was 16,436 pounds, valued at $641, as compared with 62,957 pounds in 1915, valued at $2,959.

The values for gold and silver in the table bear no relation to the quantity of ore for the reason that deep-mine and placer-mine gold and silver are combined to make the total. Of the total production of gold in 1915, $1,379,626 was from deep mines and $482,170 from placers of various kinds. Of the total of 117,947 fine ounces of silver in 1915, 112,420 ounces came from deep mines and 5,527 from placers.

The mine production of Oregon, having a total value of $2,003,509 in 1915, was derived from 95 producing mines, of which 65 were placer and 30 deep. The producing placers decreased by 12 in 1915 and the producing mines increased by 2. The total quantity of ore sold or treated was 155,791 tons, an increase of 31,460 tons. The quantity of siliceous ore sold or treated was 151,076 tons, an increase of 26,802 tons. There were 3,722 tons of copper ore sold or treated in 1915, whereas there was no purely copper ore mined in 1914. The lead ore treated or sold amounted to 993 tons, which, aside from lead content, was valued at $3.44 a ton in gold and silver. The copper ore averaged $1.80 a ton in gold and silver. The average value of the siliceous ore in 1915 was $9.44 a ton, as compared with $8.99 a ton in 1914; $8.21, in 1913; $6.84, in 1912; $5.03, in 1911; $6.42, in 1910; $9.87, in 1909; and $12.49, in 1908. Altogether the 155,791 tons of ore had an average value per ton of $9.22 in gold and silver.

There were treated at gold and silver mills in 1915 in Oregon 130,863 tons of ore, yielding $1,345,187 in gold, and 97,341 ounces of silver, valued at $49,352. In milling the ore at gold and silver mills $1,270,930 in gold and 95,990 fine ounces of silver were recovered by amalgamation and cyanidation, the average value per ton being $9.71 in gold and 37 cents in silver. From these 130,803 tons of milling ore were recovered 953 tons of concentrates, having a value in gold of $74,257 and 1,351 ounces of silver, valued at $685, a total of $74,942, and an average value per ton of $77.92 in gold and $0.719 in silver. Crude ore shipped to smelters amounted to 4,781 tons and contained $8,586 in gold and 13,872 ounces of silver, an average value per ton of $1.80 in gold and $1.47 in silver. The 993 tons of purely lead ores shipped to smelters, yielded in lead 52,617 pounds, or 53 pounds per ton. The 3,722 tons of copper ore shipped to smelter yielded 445,131 pounds of copper, or an average of about 120 pounds a ton. There were 20,147 tons of old tailings treated that yielded $25,853 in gold and 1,207 ounces of silver, an average value per ton of $1.28 in gold and $0.03 in silver.

GOLD.

The total recoverable gold content of ores and the gold from placers in Oregon in 1915 was 90,064.38 fine ounces, valued at $1,861,796, an increase of 13,077.46 fine ounces in quantity and of $270,335 in value. The largest yield of gold from one county, valued at $1,685,382 came, as usual, from Baker County. The increase in this county in 1915 was $371,415, as compared with the yield in 1914. The next county in rank of gold production was Josephine, with $85,082, or a decrease of $26,346. Other counties in rank of production of gold are Malheur, Jackson, Lane, Grant, Crook, Douglas, Wheeler, Curry, Clackamas, Marion, and Union. The placer mines of the State produced $482,170

in gold in 1915, as compared with $548,317 in 1914, a decrease of $66,147. The hydraulic mines produced $115,013 in 1905, or $63,886 less than in 1914; the drift mines $2,066, or $2,360 less; the surface placers and dredges combined $365,091, or $99 more. There were two dredges operating in Oregon in 1915. There were 52 productive hydraulic mines in 1915, as compared with 56 in 1914. There were 4 drift and 7 placer mines productive in 1915.

The total output of gold from deep mines was 66,739.41 fine ounces, valued at $1,379,626, which was 16,277.32 ounces more in quantity and $336,482 more in value than in 1914. Of the gold derived from deep mines $390,143 was recovered by amalgamation and $906,640 by cyanidation. In Oregon there were no chlorination plants, and the concentrates obtained were shipped generally to smelters for treatment.

Mine production of gold in Oregon in 1915, by sources, in fine ounces.

County.	Placers.	Deep mines.				Grand total.
		Siliceous ore.	Copper ore.	Lead ore.	Total.	
Baker	17,604.05	63,871.30	55.00	.....	63,926.30	81,530.35
Clackamas	.....	35.99	.....	.....	35.99	35.99
Crook	266.06	18.00	.....	.....	18.00	284.06
Curry	38.99	.....	.....	.....	.....	38.99
Douglas	116.54	.....	.....	.....	.....	116.54
Grant	66.23	235.97	.....	.....	235.97	302.20
Jackson	1,216.63	244.34	.....	.....	244.34	1,460.97
Josephine	3,400.71	604.11	28.01	83.01	715.13	4,115.84
Lane	.....	470.11	.....	.....	470.11	470.11
Malheur	566.28	1,061.01	.....	.....	1,061.01	1,627.29
Marion	.....	32.56	.....	.....	32.56	32.56
Union	7.01	.....	.....	.....	.....	7.01
Wheeler	42.47	.....	.....	.....	.....	42.47
	23,324.97	66,573.39	83.01	83.01	66,739.41	90,064.38
Increase or decrease	−3,199.86	+16,185.07	+83.01	+9.24	+16,277.32	+13,077.46

Value of output of placer gold in Oregon in 1915.

County.	Hydraulic.	Drift.	Dredging and surface.	Surface placers.	Total.
Baker	$9,716	$1,317	$352,875	.....	$363,908
Crook	.....	.....	.....	$5,500	5,500
Curry	806	.....	.....	.....	806
Douglas	2,409	.....	.....	.....	2,409
Grant	1,369	.....	.....	.....	1,369
Jackson	24,902	248	.....	.....	25,150
Josephine	69,422	501	.....	376	70,299
Malheur	5,366	.....	.....	6,340	11,706
Union	145	.....	.....	.....	145
Wheeler	878	.....	.....	.....	878
	115,013	2,066	[a] 352,875	12,216	482,170

[a] Includes surface placers in Baker County.

Increase or decrease in value of mine production of gold in Oregon in 1915.

County.	Increase.	Decrease.
Baker	$371,415	
Clackamas	744	
Coos		$1,186
Crook		887
Curry	195	
Douglas		2,318
Grant		53,651
Jackson		9,305
Josephine		26,346
Lane	7,091	
Malheur		16,413
Marion	673	
Union	145	
Wheeler	178	
	380,441	110,106
Net increase in 1915	270,335	

SILVER.

The recoverable silver content of ores and the silver from placers in Oregon in 1915 aggregated 117,947 fine ounces, valued at $59,799, a decrease of 24,605 ounces in quantity and of $19,032 in value. Baker County in 1915, made the largest output of silver, 110,124 fine ounces, valued at $55,833. No other county in the State produced as much as 5,000 ounces, the nearest being Josephine County with 4,048 ounces, valued at $2,052. The placer mines of Oregon produced 5,527 fine ounces, valued at $2,802, as compared with 5,512 ounces, valued at $3,048 in 1914. The deep mines produced 112,420 fine ounces, valued at $56,997; of this quantity 9,807 ounces were derived from copper ores and 3,349 ounces from lead ores, the remainder, 99,264 ounces, being derived from siliceous ore. Most of the silver derived from deep mines, 73,822 ounces, was recovered by cyanidation. The silver recovered by amalgamation amounted to only 23,375 ounces.

Mine production of silver in Oregon in 1915, by sources, in fine ounces.

County.	Placers.	Deep mines.				Grand total.
		Siliceous ore.	Copper ore.	Lead ore.	Total.	
Baker	4,540	95,781	9,803		105,584	110,124
Clackamas		41			41	41
Crook	39	4			4	43
Curry	6					6
Douglas	26					26
Grant	14	1,428			1,428	1,442
Jackson	221	546			546	767
Josephine	578	117	4	3,349	3,470	4,048
Lane		57			57	57
Malheur	93	1,284			1,284	1,377
Marion		6			6	6
Union	2					2
Wheeler	8					8
Total	5,527	99,264	9,807	3,349	112,420	117,947
Increase or decrease	+15	−37,134	+9,807	+2,707	−24,620	−24,605

COPPER.

The mine production of copper in Oregon in 1915 was 451,172 pounds, valued at $78,955, as compared with 39,248 pounds in 1914, valued at $5,220. This is an increase for 1915 of 411,924 pounds in quantity and of $73,735 in value.

LEAD.

In 1915 Oregon produced 62,957 pounds of lead, valued at $2,959, as compared with 16,436 pounds, valued at $641, in 1914. Lead was produced in the counties of Baker, Josephine, and Lane, by far the larger proportion being derived from Josephine County.

MINING INDUSTRY IN OREGON IN 1915.

Oregon produced more gold, copper, and lead, but less silver in 1915 than in 1914, the total increase being $327,356, or 20 per cent. There were 95 productive mines in the State reporting in 1915, as compared with 105 in 1914. The placer mines decreased their gold output in 1915, as compared with 1914, by $66,147, but the deep mines increased their yield during the same period by $336,482, thus making a net increase in gold for the year 1915 of $270,335.

There are very few extensive mining operations in Oregon, most of them being conducted in a small way by individuals. There are only five mines in the State which produced over $100,000 each, all in Baker County. Of these four are deep mines and the other is a dredging property. The deep mines are the Baker Mines, Columbia Mining Co., Cornucopia Mines Co., and Commercial Mining Co.; and the placer is the Powder River Dredge Co. Aside from the dredge only two placers produced over $10,000 in 1915.

The southwestern counties of Oregon,[1] which form an extension of the California gold belt, are Benton, Coos, Curry, Douglas, Jackson, Josephine, and Lane. These counties (with the exception of Benton and Coos, from which no product was reported) made in 1915 a combined production of $128,216 in gold, and 4,904 ounces of silver, valued at $2,486. The production of placer gold in this region in 1915 was $98,664, a decrease of $42,973, and the production of gold from deep mines was $29,552, an increase of $11,104. The total decrease in output of gold in these southwestern counties in 1915, as compared with 1914, was therefore $31,869.

Northeastern Oregon comprises the counties of Baker, Crook, Grant, Harney, Malheur, Umatilla, Union, Wallowa, and Wheeler. In 1915 the counties of Harney, Umatilla, and Wallowa made no metallic output. The combined gold output of the six producing counties of this region—Baker, Crook, Grant, Malheur, Union, and Wheeler—in 1915 was $1,732,163, of which Baker County contributed $1,685,382, or 97 per cent. There was an increase for 1915 of these counties, as compared with 1914, of $300,787. The yield of placer gold in 1915 was $383,506, a decrease of $23,174, or 6 per cent. The lode mines produced in gold $1,348,657 in 1915, as compared with $1,024,696 in 1914, an increase of $323,961, or 32 per cent.

The remainder of the gold production of Oregon, $1,417, was derived from mines in Marion and Clackamas counties.

[1] Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, pp. 9–127, 1914. Diller, J. S., and Kay, G. F., Mines of the Riddles quadrangle, Oreg.: U. S. Geol. Survey Bull. 340, pp. 134–152, 1908.

Gold and silver produced in Oregon in 1915, by methods of treatment.

County.	Ore to gold and silver mills.			Concentrates produced.		
	Quantity.	Gold.	Silver.	Quantity.	Gold.	Silver.
	Short tons.		*Fine ounces.*	*Short tons.*		*Fin ounces.*
Baker	121,614	$1,229,102	95,112	795	$64,672	351
Clackamas	29	744	42	.....	.....	.....
Crook	31	372	4	.....	.....	.....
Grant	217	2,150	312	.....	.....	.....
Jackson	297	3,191	53	1	144	4
Josephine	1,267	12,488	116	.....	.....	.....
Lane	2,142	6,127	37	73	3,591	20
Malheur	5,248	16,083	308	84	5,850	976
Marion	18	673	6	.....	.....	.....
	130,863	1,270,930	95,990	953	74,257	1,351
Average per ton	.....	$9.71	$0.372	.....	$77.92	0.719

County.	Crude ore to smelter.			Old tailing treated.		
	Qunatity.	Gold.	Silver.	Quantity.	Gold.	Silver.
	Short tons.		*Fine ounces.*	*Short tons.*		*Fine ounces.*
Baker	3,613	4,575	10,030	18,500	$23,125	91
Clackamas	.....	.....	.....	.....	.....	.....
Crook	.....	.....	.....	.....	.....	.....
Grant	.....	.....	.....	1,647	2,728	1,116
Jackson	18	1,716	489	.....	.....	.....
Josephine	1,150	2,295	3,353	.....	.....	.....
Lane	.....	.....	.....	.....	.....	.....
Malheur	.....	.....	.....	.....	.....	.....
Marion	.....	.....	.....	.....	.....	.....
	4,781	8,586	13,872	20,147	25,853	1,207
Average value per ton	.....	$1.80	1.47	.....	$1.28	0.033

Ore sold or treated in Oregon in 1915, in short tons.

County.	Siliceous ore.	Copper ore.	Lead ore.	Total ore.
Baker	140,162	3,565	.....	143,727
Clackamas	29	.....	.....	29
Crook	31	.....	.....	31
Grant	1,864	.....	.....	1,864
Jackson	315	.....	.....	315
Josephine	1,267	157	993	2,417
Lane	2,142	.....	.....	2,142
Malheur	5,248	.....	.....	5,248
Marion	18	.....	.....	18
	151,076	3,722	993	155,791
Increase	26,802	3,722	936	31,460
Value per ton in gold and silver	$9.44	$1.80	$3.44	$9.22

Production of gold, silver, copper, and lead in Oregon in 1915.

County.	Ore.	Quartz gold.		Placer gold.		Total gold.	
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Short tons.	*Fine ounces.*		*Fine ounces.*		*Fine ounces.*	
Baker	143,727	63,926.30	$1,321,474	17,604.05	$363,908	81,530.35	$1,685,382
Clackamas	29	35.99	744			35.99	744
Crook	31	18.00	372	266.06	5,500	284.06	5,872
Curry				38.99	806	38.99	806
Douglas				116.54	2,409	116.54	2,409
Grant	1,864	235.97	4,878	66.23	1,369	302.20	6,247
Jackson	315	244.34	5,051	1,216.63	25,150	1,460.97	30,201
Josephine	2,417	715.13	14,783	3,400.71	70,299	4,115.84	85,082
Lane	2,142	470.11	9,718			470.11	9,718
Malheur	5,248	1,061.01	21,933	566.28	11,706	1,627.29	33,639
Marion	18	32.56	673			32.56	673
Union				7.01	145	7.01	145
Wheeler				42.47	878	42.47	878
	155,791	66,739.41	1,379,626	23,324.97	482 170	90,064.38	1,861,796

County.	Quartz silver.		Placer silver.		Total silver.	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
	Fine ounces.		*Fine ounces.*		*Fine ounces.*	
Baker	105,584	$53,531	4,540	$2,302	110,124	$55,833
Clackamas	41	21			41	21
Crook	4	2	39	20	43	22
Curry			6	3	6	3
Douglas			26	13	26	13
Grant	1,428	724	14	7	1,442	731
Jackson	546	277	221	112	767	389
Josephine	3,470	1,759	578	293	4,048	2,052
Lane	57	29			57	29
Malheur	1,284	651	93	47	1,377	698
Marion	6	3			6	3
Union			2	1	2	1
Wheeler			8	4	8	4
	112,420	56,997	5,527	2,802	117,947	59,799

County.	Copper.		Lead.		Total value.
	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		
Baker	397,103	$69,493	1,872	$88	$1,810,796
Clackamas					765
Crook					5,894
Curry					809
Douglas					2,422
Grant					6,978
Jackson			2,489	117	30,707
Josephine	53,663	9,391	52,617	2,473	98,998
Lane	406	71	5,979	281	10,099
Malheur					34,337
Marion					676
Union					146
Wheeler					882
	451,172	78,955	62,957	2,959	2,003,509

PRODUCTION BY COUNTIES.

BAKER COUNTY.

The total value of all metals mined in Baker County in 1915 was $1,810,796, as compared with $1,346,717 for 1914, an increase of $464,079. This was due to the increased output of ore from deep mines, which produced 46,005 tons more than in 1914, with a resulting increase of $376,989 in gold and 51,767 ounces of silver, valued at $23,770 in 1915, as compared with 1914. The output of copper in the county increased in 1915, as compared with 1914, by 396,411 pounds in quantity and $69,401 in value. The lead output decreased in quantity 9,307 pounds and in value $348. The total increase in all metals from the deep mines in 1915, as compared with 1914, was therefore $469,812. The placer mines of the county produced $363,908 in gold in 1915, a decrease of $5,574. The placer silver produced in 1915 was 4,540 ounces, valued at $2,302, a decrease in value of $159. There were 26 producing mines in the county in 1915, as compared with 19 in 1914. The number of producing deep mines was 12 and of placer mines 14. The total output of siliceous ore mined and treated in the county in 1915 was 140,162 tons, or 42,497 tons more than in 1914. The gold from this ore was valued at $1,320,337 and the silver amounted to 95,781 fine ounces, valued at $48,561. The average recoverable value of the ore per ton was $9.42 in gold and 35 cents in silver, a total value per ton of $9.77, as compared with $9.66 in gold and 30 cents in silver, a total value per ton of $9.96 in 1914; $8.66 in gold and 39 cents in silver, a total of $9.05 in 1913; $6.32 in gold and 34 cents in silver, a total of $6.66 in 1912; and $4.99 in gold and 22 cents in silver, a total of $5.21 in 1911.

Of the 140,162 tons of siliceous ore, 121,614 tons were treated at gold and silver mills and produced $1,229,102 in gold and 95,112 ounces of silver (valued at $48,222) by amalgamation and cyanidation, an average per ton of $10.01 in gold and 39 cents in silver. From the the 140,162 tons of milling ore were derived 795 tons of concentrates producing $64,672 in gold and 351 ounces of silver (valued at $178), a total value of $64,850, or an average value per ton of $81.57. The total yield of the 140,162 tons of milling ore from the plates from direct cyanidation and from the concentrates was $1,293,774 in gold and $48,400 in silver, an average per ton of $9.23 in gold and 34 cents in silver, a total recovery per ton of $9.57 in gold and silver. In addition 3,613 tons of ore were shipped to smelters, yielding in gold $4,575 and in silver 10,030 ounces, valued at $5,085, a total value of smelting ores of $9,660 in gold and silver, or an average per ton of $2.67. There were 18,500 tons of old tailings treated, yielding $23,125 in gold and 91 ounces of silver, valued at $46, or a total value of $23,171, being an average value of $1.25 a ton.

Baker district.—Two placer mines were productive in this district in 1915, their output being $18,126 in gold and $106 in silver. This was $6,386 more than 1914. No deep mines reported product from this district in 1915.

Cable Cove district.—One deep mine reported product from this district in 1915.

Cornucopia district.—This was the most productive district in Oregon, the four deep mines working having a total yield of $861,987 in gold and silver in 1915. The most important of these mines was

that of Cornucopia Mines Co., of New York, which is developed by a 1,500-foot adit and an 800-foot incline shaft, the latter having been sunk 200 feet in 1915. The ore treatment process is by primary stamp crushing, regrinding in tube mills, and slime-cyanide process. The Baker mines Co., another important enterprise, did 3,200 feet of development work in 1915 and installed a new compressor and also a water-power plant consisting of pressure pipe line and Pelton water wheel to develop 125 horsepower. The property is equipped with a 20-stamp amalgamation and cyanide plant. The Bonanza Mining Co. has a 30-stamp mill with concentration, but only 10-stamps were run in 1915. The Eccentric is a deep mine, which had a small output.

Cracker Creek district.—Next to Cornucopia this was the most productive district in Baker County and in the State. The most important deep mine is the Columbia, in which 5,600 feet of drifting and raising was done in 1915. The crude ore and concentrates from this mine are shipped to the smelter. Old tailings are treated at the cyanide plant at the mine. There was 1 drift mine in the district, the Surprise, and 3 hydraulic mines, the Clark Creek Farm, Buck Gulch, and the Chicken Creek. The most productive property in the district was that of the Powder River Dredge Co., which operated 2 dredges in 1915.

Granite district.—In this district the Snyder Consolidated Mining Co. operated a drift mine in a small way.

Greenhorn district.—The Trinity hydraulic mine was the only productive property in this district.

Iron Dyke district.—The Homestead Iron Dyke mine shipped copper ore carrying also gold and silver to Salt Lake smelters.

Mormon Basin district.—In this district there were two deep and two placer mines which were productive. The placers were the Colt and the Rye Valley, both hydraulic mines. The deep mines were the Commercial Mining Co. and the Summit Mining Co. The total output of the district in 1915 was $386,605 in gold, and 3,635 ounces of silver, valued at $1,843, a total of $370,448, making this the third district in importance of output in Baker County, exceeded only by Cornucopia and Cracker Creek districts. The Commercial Mining Co. is one of the largest enterprises in Oregon, having a 400-foot shaft and three levels from 200 to 1,400 feet long. The mine is equipped with a 15-stamp amalgamation mill and cyanide plant. The mine was formerly known as the Rainbow. The Summit has a five-stamp amalgamation mill.

Pine Creek and Virtue districts.—In Pine Creek district there were only two small placers, both hydraulic mines. In Virtue district one deep mine only was productive in a small way.

Weatherby district.—The two productive mines in this district were the Piute and the Little Hill.

CLACKAMAS, CROOK, AND CURRY COUNTIES.

In Clackamas County the Ogle Mountain Mining Co. operated in China Creek district in a small way. In Crook County the productive deep mine was that of the Ophir Mayflower Mining Co., in Howard district, and the same company operated a small gravel mine. In Curry County a small hydraulic mine in Mule Creek district was operated by G. M. Cheney.

DOUGLAS COUNTY.

There were only a few mines in this county which were productive in 1915, and these were all operated by the hydraulic system. These were the Boulder, Hogan, Starvout Nugget, and Picune, in Green Mountain district; the Buck Fork, in Myrtle Creek district; and some small placers in Coffee Creek district.

GRANT COUNTY.

The whole output of this county in 1915 was only $6,978 in gold and silver, which was derived from five mines, two deep and three placers. The deep mines were the Red Boy and the Glenn Development Co., in Granite district, and the hydraulic mines were the Poker, in Poker Flat district, and the Gray Eagle and Quartz Gulch, in Canyon district.

JACKSON COUNTY.

There were four producing deep mines in Jackson County, and seven placers, or five less than in 1914. The placers were all hydraulic mines, which made a combined production of $25,150 in gold and $112 in silver in 1915, a total of $25,262. The principal ones were the Layton, in Applegate district; Blue Ridge, Spaulding, and Sterling, in Forest Creek district; and Sperry or Maybright, in Sardine Creek district. Of the deep mines, the Grubstake, in Blue Ledge district, has a water-driven arrastre, with a 1-ton cyanide plant put at work in 1915. The largest producing deep mine was the Opp, in the Jacksonville district. The Pearl mine is in Pearl district, and the Lone Pine is in Kanes Creek district. These deep mines in the county made a combined output of gold and silver of $5,328 in 1915. The total output of the county in gold and silver and lead in 1915 was valued at $30,707.

JOSEPHINE COUNTY.

The total output of gold, silver, copper, and lead in Josephine County in 1915 was valued at $98,998, as compared with $123,734 in 1914, a decrease of $24,736. The gold yield was $85,082; the silver, 4,048 ounces, valued at $2,052; the copper, 53,663 pounds, valued at $9,391; and the lead, 52,617 pounds, valued at $2,473. The seven deep mines of the county produced from 2,417 tons of ore $14,783 in gold; 3,470 ounces of silver, valued at $1,759; 53,663 pounds of copper, valued at $9,391; and 52,617 pounds of lead, valued at $2,473. The total value of the deep-mine product of the county was therefore $28,406. Of the total output of placer gold of $70,299, the hydraulic mines produced $69,422; the remainder was derived from small drift and surface placers. The decrease in placer gold in the county in 1915 was $33,193. The decrease in total production of gold for 1915, as compared with 1914, was $26,346. Of the 2,417 tons of ore produced in the county, 1,267 tons were treated at gold and silver mills, and 1,150 tons were shipped to smelters.

Mine production of gold, silver, copper, and lead in Josephine County, Oreg., in 1915.

District.	Placer gold.	Quartz gold.	Placer silver.	Quartz silver.	Copper.		Lead.		Total value.
					Quantity.	Value.	Quantity.	Value.	
					Pounds.		*Pounds.*		
Althouse	$1,879		$7						$1,886
Galice	12,023	$1,716	43	$1,698	5,503	$963	52,617	$2,473	18,916
Grave Creek	552		3						555
Josephine	3,969	10,338	19	47	48,160	8,428			22,801
Jump Off Joe	20,159		99						20,258
Pickett Creek	1,000		5						1,005
Placer	22,863		89						22,952
Sucker Creek		2,000		11					2,011
Waldo	3,457		12						3,469
Williams	1,090		5						1,095
Wolf Creek	3,307	729	11	3					4,050
	70,299	14,783	293	1,759	53,663	9,391	52,617	2,473	98,908

The producing mines in Althouse district were the Goldsby and the Little Homestead placers.

There were two hydraulic mines in Galice district, the Oregon Placer Mining Co. and the Martin & Daniels, and there were a few small placers. The only deep mine was that of the Almeda Consolidated Mines Co., which is equipped with a 100-ton water-jacket blast furnace, and ships its matte to the Tacoma smelter. The plant was only operated for a brief period in 1915.

Four deep mines reported production from Josephine district. The Waldo Copper Co. (Elder) was operated half the year to test the mine at depth, and copper ore was shipped to the mammoth smelter at Kennett, Cal. The Queen of Bronze, Jack Rabbit, and Gold Bend were also productive.

In Jump Off Joe district the Cook & Howland and Ohio No. 5 hydraulic mines were productive.

Wolf Creek district had one deep mine, the Sylvanite, and two gravel mines, the Blue Channel hydraulic and the Copper Knob surface placer.

In Grave Creek district there was one productive hydraulic mine; in Pickett Creek district, one hydraulic mine; Placer district, one hydraulic mine; Sucker Creek district, one deep mine; Williams district, a few small hydraulic mines.

MALHEUR COUNTY.

Malheur County had three producing hydraulic mines, the Boswell, Quartz Gulch, and the Archer & Hansen, and a few small sluicing mines, as well as one deep mine. The deep mine was that of the Humboldt Consolidated Co., which has a 20-stamp amalgamation and concentration mill. This property is developed by a 500-foot vertical shaft and 3,500 feet of drifts, and a good deal of development work was done in 1915, the property having been operated throughout the year.

LANE, MARION, UNION, AND WHEELER COUNTIES.

In Lane County one deep mine was productive in 1915, and one also in Marion County. In Union County there was one productive hydraulic mine; and in Wheeler County there were two mines, both hydraulic properties.

QUICKSILVER.[1]

By H. D. McCaskey.

INTRODUCTION.

The quicksilver industry continued to be of more than usual interest throughout 1915, owing to the large consumption of the metal in the manufacture of war supplies and the generally prevailing high prices resulting from the great demand. Soon after the outbreak of the war foreign embargoes on the exportation of metals made it seem that domestic producers would control the market in the United States during the war, and several shipments from Italy, made, it is reported, under contracts drawn prior to the disturbed conditions abroad, did not prevent a soaring market through 1915 and extending to March, 1916. Prices for the metal became so high in February and March, 1916, that domestic contractors for the Allies induced the British Government to permit shipments of quicksilver to this country to complete contracts, and thus, to a small but important extent, competition in the home market between domestic and foreign supplies was reestablished and prices rapidly fell from $300 per flask in February, 1916, to $75, the price now (August, 1916). Although, owing to the efforts of producers to make capacity output, some stocks have probably accumulated, the price of quicksilver at London will probably justify exports from this country and cause reduction of stocks if the domestic quotations run much below $70. Therefore it would seem that producers here may count upon a fair price for their metal, possibly not below $1 a pound, during the war.

The quicksilver mines and prospects of the United States were generally under active development in 1915, and additions to reduction plants were made at old mines and retorts were put in operation at promising prospects. Hopes for large profits from new developments may not be realized, but the industry as a whole has now enjoyed at least one full year of real prosperity and may reasonably look forward to continuance of present favorable conditions to the end of 1916 at least.

The natural tendency during "booms" and times of unusually high prices to devote considerable sums to develop unproved properties and to experiment with untried methods of mining and reduction, may not prove altogether profitable to investors in all cases, for undoubtedly some ventures are inherently speculative, some are inefficiently developed, and others are based upon optimism almost

[1] The statistical tables of this report were compiled by Mrs. H. L. Bennit.

as a sole asset; but whatever material development and experimentation wisely and skillfully directed can be paid for by general prosperity must be more or less a permanent gain to the industry as a whole. The extent and value of workable deposits and the practicability of various metallurgical methods should be better understood than before.

USES OF QUICKSILVER.

Quicksilver is used mainly in the manufacture of fulminate for explosive caps, of drugs (calomel, mercuric chloride, etc.), of paint (vermilion), of electrical appliances and scientific apparatus (thermometers, barometers, etc.), and in the recovery by amalgamation of precious metals, especially gold. It is little employed now for silvering mirrors, being replaced by silver nitrate. Mercuric oxide (red oxide of mercury) has also been used as a paint to a considerable extent as an active poison to prevent fouling of ships' bottoms. It is reported also that experiments have been made looking toward the use of the metal in new ways to prevent iron rust and to conserve heat in the generation of steam, but details of these experiments are not available to the Survey. Undoubtedly engineers, physicists, and chemists will further experiment with the metal should prices fall to their old levels and large supplies seem available under normal conditions.

The former principal demand for the metal—for the amalgamation of precious metals—has greatly declined with increase of cyanidation and decrease of supplies of free-milling ores, and also with the increased efficiency and economy in stamp-milling practice, whereby losses of quicksilver have been reduced. The following table compiled by the Survey indicates the quantities of quicksilver consumed in western stamp mills in recent years:

Quicksilver consumed in gold mining, 1912–1914, in pounds.

State.	1912	1913	1914
Alaska [a]	15,000	15,000	18,000
Arizona	[a] 1,400	[a] 1,500	[b] 1,802
California [a]	45,000	45,000	45,000
Colorado [c]	10,622	10,834	6,059
Idaho [d]	700	254	598
Montana	[a] 750	[a] 200	[b] 408
Nevada	[a] 1,500	[a] 1,600	[b] 6,826
New Mexico [c]	187	133	365
Oregon [a]	260	350	400
South Dakota [c]	14,095	12,150	13,500
Utah	[a] 40	[a] 30	[b] 20
Washington [d]	121	130	43
	89,675	87,181	93,021

[a] Estimate based on bullion recovered by stamp milling.
[b] Heikes, V. C., U. S. Geol. Survey Mineral Resources.
[c] Henderson, C. W., idem.
[d] Gerry, C. N., idem.

These figures indicate a consumption of but little more than 6 per cent of the domestic production for the three years 1912–1914. In normal times probably between 30 and 40 per cent of the domestic output has been sold for manufacture into fulminate; at the present time possibly double this proportion. One flask of 75 pounds of mercury will make 100 to 120 pounds of this powerful detonator. Before the European war, according to report, mecuric fulminate for use in blast-

ing caps was made both in this country and in Canada from domestic metal and comparatively little metal was used here in making percussion caps for rifle cartridges. Since the war began fulminate has been made in Canada and the United States from both domestic and imported metal, it is understood, and for both blasting and rifle caps in greatly increased quantity. In normal times the remainder of the domestic output has probably been consumed chiefly in the manufacture of various drugs and other chemical compounds, some has been exported, and some has accumulated as stocks. Efforts made by the Survey during the preparation of this report to learn from dealers more accurately the quantitative consumption of the metal have not been fruitful of results. The trade has always been conservative and not given to publicity. A few replies to inquiries were made in detail, but information is still lacking for accurate estimation of consumption by various uses. It may generally be assumed, however, that for all the principal uses of quicksilver there has been increased demand.

PRODUCTION.

NUMBER OF MINES, METAL OUPUT, AND VALUE.

Including small prospects there were 39 producers of quicksilver in the United States in 1915, against 30 in 1914 and 24 in 1913. There are usually a few mines or prospects (under development only) that produce ore but no metal and a few that produce metal only from old dumps and furnace material of earlier years. In the enumeration producers of metal are included, but not mines and prospects under development only. Thirty-two of the producers in 1915 were in California (an increase of 12), 4 were in Nevada (a decrease of 3), and there was 1 producer each in Arizona, Oregon, and Texas. There was no output reported from Utah or Washington, and Arizona has produced only in a small way.

According to confidential returns to the Geological Survey from every producing district, the output of quicksilver in the United States in 1915, was 21,033 flasks of 75 pounds each, against 16,548 flasks in 1914 and 20,213 flasks in 1913. The production of 1914 was the smallest since 1860 and that of 1915, even with its relatively large increase over 1914, was below the average of 25,225 flasks for the preceding 13 years. With present high prices the output may be maintained around 20,000 flasks a year, but in general the industry is not backed by known reserves of ore justifying the prediction of a greatly increased yield.

At the average sales price reported by the producers of $86.86 per flask for 1915 the output was valued at $1,826,912, the highest value since 1880. In 1914 the value (based on average quotations published in the Mining and Scientific Press for San Francisco domestic) was $811,680 and in 1913 it was $813,171. Compared with 1914, the yield for 1915 showed an increase in quantity of 27 per cent, but of 125 per cent in value.

The production of California increased 26 per cent in quantity and 112 per cent in value in 1915, against decreases in both quantity and value in 1914. The output of Nevada continued to increase—11 per cent in quantity and 105 per cent in value in 1915. The production of Arizona, Oregon, and Texas, combined, increased 40 per cent

in quantity and 186 per cent in value in 1915 over the output for Arizona and Texas, combined, in 1914.

Quicksilver produced in the United States, 1913–1915, in flasks of 75 pounds.

State.	1913		1914		1915	
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.
Arizona, Oregon[a], Texas	2,977	$119,765	3,156	$154,801	4,423	$442,120
California	15,591	627,228	11,303	554,414	14,283	1,174,881
Nevada	1,645	66,178	2,089	102,465	2,327	209,911
	20,213	813,171	16,548	811,680	21,033	1,826,912

[a] Oregon had no output in 1913 and 1914.

ORE TREATED AND RECOVERY OF METAL.

According to reports from the producers, 169,939 short tons of new ore were mined and available for treatment in 1915, a considerable increase over the quantity in 1914, due, of course, to increased development and prospecting as well as to more rapid exploitation of established mines to take advantage of high prizes.

Of new and old ore and old furnace material 158,817 short tons were treated in 1915, averaging 0.4 per cent quicksilver, or 9.9 pounds per ton, an increase in quantity of 35,819 tons but with a slight decrease in tenor, owing chiefly to the lower-grade ore worked in Nevada.

In California 129,521 short tons of ore, averaging 0.41 per cent of metal, or 8.3 pounds of quicksilver per ton, were treated, against 101,553 tons of the same grade in 1914. In Nevada 21,975 tons, averaging 0.4 per cent, or 7.9 pounds of metal per ton of ore, were treated in 1915, against 14,111 tons of somewhat higher-grade ore in 1914. In Arizona, Oregon, and Texas, combined, 7,321 tons of ore, averaging 2.27 per cent, were treated in 1915, against a trifle more than this quantity from Arizona and Texas, averaging 1.62 per cent, in 1914.

Quicksilver ore treated and average recoveries, 1914 and 1915.

State.	1914			1915		
	Short tons treated.	Pounds of metal recovered per ton.	Percentage of ore recovered as metal.	Short tons treated.	Pounds of metal recovered per ton.	Percentage of ore recovered as metal.
Arizona, Oregon[a], Texas	7,334	32.3	1.62	7,321	45.3	2.27
California	101,553	8.3	.42	129,521	8.3	.41
Nevada	14,111	11.1	.56	21,975	7.9	.40
	122,998	10.1	.505	158,817	9.9	.497

[a] Oregon had no output in 1914.

The table below has been prepared to show the relative importance of shaft furnaces and retorts in the production of domestic quicksilver. A total of only 2,391 tons was treated in retorts, yielding 1,214 flasks of quicksilver, or 1.9 per cent, of metal from the ore charged. On the other hand, 156,426 tons of lower-grade ore were treated in shaft furnaces, yielding 19,819 flasks of mercury, or an average of 0.48 per cent of metal.

Quicksilver ore treated in retorts and in furnaces in 1915.

State.	Ore treated, short tons.		Quicksilver recovered, flasks.		Percentage of metal recovered per ton of ore treated.	
	Retorts.	Furnaces.	Retorts.	Furnaces.	Retorts.	Furnaces.
California	2,270	127,251	1,160	13,123	1.92	0.39
Other States[a]	121	29,175	54	6,696	1.67	.86
	2,391	156,426	1,214	19,819	1.90	.48

[a] Includes Arizona, Nevada, Oregon, and Texas.

METHODS OF TREATMENT.

Brief notes on the treatment of quicksilver ores and references to the literature of the subject have been given in preceding Survey reports, copies of which are still available for distribution.

The best discussion of quicksilver metallurgy in California to the date of its publication (1903) was that by Forstner in Bulletin 27 of the California State Mining Bureau, "The quicksilver resources of California." This most practical and useful bulletin is now exhausted, but copies can probably be consulted in the larger libraries. A new bulletin by that bureau it is understood is now in preparation.

A recent valuable discussion of the general subject is that by Herbert Lang, on "Quicksilver reduction," in the Mining and Scientific Press, for May 13, 1916.

Owing to the interest in the possibility of concentrating very low grade ores and old dumps, of which large quantities are undoubtedly available in California, Fletcher Hamilton, State mineralogist of California, took up the subject, and after some preliminary investigation issued the following interesting statement from the California Mining Bureau in its Press Bulletin No. 36, dated May 15, 1916:

An investigation is being conducted as to the feasibility and the scope of application of concentrating methods for reduction of quicksilver ores. The experimental work is being carried on in the mill of the Department of Mining at the University of California, Berkeley, by Walter W. Bradley, of the staff of the State Mining Bureau. Much experimental work has yet to be done, but sufficient data have been gained, so far, to make a preliminary statement of partial results, pending the issuance of the final report in bulletin form later. This is done in the hope that it may assist those who are making inquiries along these lines, and also that it may elicit suggestions from those who are similarly experimenting at various mines throughout the State.

Aside from the present war-begotten flurry of high prices, quicksilver mining in California has become more and more a question of economically handling larger tonnages of lower-grade ores. Since Robert Scott evolved his fine-ore tile furnace in 1871, there have been no improvements worthy of mention in the metallurgy of quicksilver until the present agitation for concentrating. A very surprising feature of the situation, particularly to one familiar with metallurgical practices in the reduction of gold, silver, copper, etc., is the absolute lack of any systematic sampling and

assaying at the quicksilver mines. So far as we have observed, there is not a quicksilver mine in California which possesses or utilizes an assay office; at least there was none up to within the last six months. The distillation assay with the "Whitton" apparatus is simple, quick, and accurate. The old-timers have been complacently saying, "The furnace gets it all," and that therefore they did not need to assay. It is doubtful if the Scott fine-ore furnaces in operation in California are averaging 75 per cent extraction. In addition, they are notorious for the quicksilver absorbed by the furnace and condenser walls; also soot is formed which has to be re-treated for contained mercury. The products of fuel combustion being mixed with the vaporized mercury cause condensing troubles.

Our experiments have shown that high extraction (above 90 per cent) can be obtained by water concentration on tables with friable ores in which the cinnabar is distinctly crystalline. Crushing by rolls produces a minimum of slimes. If, however, the pulp contains a cinnabar slime, either from "paint" ores or by reason of having to crush fine to release the sulphide, the extraction by tables will be low. In such cases, though, it can be improved by classification and treating the different sizes on separate tables. The slimed cinnabar can be recovered by flotation. A high extraction has been obtained by flotation tests in finely ground (80 mesh) fresh ores, utilizing either pine oil derivatives or eucalyptus oils. We say "fresh" ores, because, contrary to common conception, cinnabar on exposure does oxidize sufficiently to affect flotation results, as some of our tests have indicated. Good results were obtained by table concentration on an ore carrying natural quicksilver.

The concentrates being obtained have yet to be roasted. Retorts are of limited capacity; and the concentrates because of their high specific gravity require stirring to prevent packing. A small furnace of the Scott type could be used, with a narrower shaft and narrow shelf-slit, such as is in use at the New Idria mine for treating soot. Here, again, we have the fuel combustion products mixed with the quicksilver vapor and the attendant condensing difficulties. Some form of rotary roaster may be adapted, or a small-size unit of the McDougall or Wedge type of mechanically rabbled furnace muffle-fired.

The ultimate decision between a straight furnace reduction or concentration and roasting of concentrates will be a matter of comparative costs coupled with comparative extractions. The initial installation of a Scott fine-ore furnace unit is high (including condensers, etc., $1,000 per ton of capacity. We know of instances where the cost has been materially less than this figure, but they are the exception rather than the rule); the extraction is low (in the majority of cases probably less than 75 per cent); cost of operation is low (50 cents to 75 cents per ton for large units, economically managed, though this does not include high cost repairs, interest, or depreciation on the high initial installation capital). A concentrating plant of equal capacity will require less than one-tenth the initial capital expenditure, and a correspondingly lower depreciation charge; it will give 25 per cent to 30 per cent higher extraction; but the operating cost, on account of finer crushing, will be 30 per cent to 50 per cent higher. These points will have to be determined upon for each individual property.

Prior to this E. M. Hamilton had communicated to the Mining and Scientific Press of April 15, 1916, the following interesting details on flotation:

In view of the present high price of mercury and the frequent references to mercury ore in your columns, it may interest your readers to know that cinnabar can be treated very successfully by flotation. The difficulty in treating this ore by mechanical concentration seems to be that with coarse crushing the larger particles of cinnabar are for some reason thrown or floated into the gangue, although a good saving is made on the fine material, while if the whole ore is crushed fine before tabling, some of the mineral is reduced too fine to be held on the table and goes off in suspension with the tailing.

By crushing the ore to pass 60-mesh we have succeeded in obtaining very high recoveries by flotation, both with the Minerals Separation type of machine and also with the Callow. For instance, a sample of Californian ore assaying 0.1 per cent mercury, crushed to pass 60-mesh and floated, gave a tailing of 0.01 per cent, as reported by one assayer, and zero, as reported by another, showing 90 per cent and 100 per cent extraction, respectively. The amount of concentrate recovered was 2.17 per cent of the original weight and assayed 4.15 per cent mercury, but as a high-grade product was not required, no attempt was made to raise the value above this point.

A sample from another district in the same State assayed 0.3 per cent mercury, and when crushed to pass 60-mesh and floated, gave a concentrate assaying 26.8 per

cent mercury in 1.12 per cent of the original bulk with a tailing of 0.03 per cent, showing a recovery of 90.95 per cent of the content.

A sample from a third district assaying 0.92 per cent had to be crushed to pass 80-mesh to obtain the best results. This yielded a concentrate containing 18 per cent mercury in 4.78 per cent of the original bulk, with a tailing of 0.06 per cent, giving an extraction of 93.7 per cent.

Still earlier Clifford G. Dennis, of San Francisco, had carried on rough preliminary experiments in the concentration of quicksilver ores by flotation and had announced that flotation could probably be successfully used. The earliest practical application of ordinary water concentration of cinnabar is probably to be credited to G. V. Northey, operating the Manzanita mine, whose successful methods of producing and retorting concentrates are well described by Forstner. Later Brör Soderhjelm, at the Aetna mine, and R. P. Newcomb, at the Oat Hill mine, both in Napa County, and others concentrated low-grade ores somewhat along the lines followed by Northey. In 1915 demand began to be made for the most modern concentrating devices for further experimentation, and it has been reported that Deister tables have been delivered to the New Idria, Oat Hill, Oceanic, and other mines and have given excellent results. It seems likely that the problem of profitable concentration of low-grade quicksilver ores will be given wide and thorough study and that some definite improvements in extraction will result. Probably many of the standard concentrating machines will be given a trial. The miner's pan and especially the horn spoon in the hands of skilled prospectors have long given good results in a small way in the examination of low-grade deposits, and it seems unlikely that the simple principles involved may not eventually be successfully applied in a large way.

Concentrates must be retorted or otherwise treated, and with the known low costs of direct furnace treatment of low-grade ore, under favorable conditions, it remains a question for each property whether the cost of added concentration equipment will pay in the long run. Probably concentration on a large scale would pay best. Possibly the concentrates of certain adaptable ores, mixed with ores from the same mine not suitable either for concentration or for direct furnace treatment alone, would result in a mixture leading to the best extraction and justify retention of reduction plants already in operation. The Hüttner-Scott tile furnace, with its condenser losses, known and unknown, may be superseded by adaptations of other types, including rotary furances, but it has proved remarkably cheap in operation and possibly further improvements in condensers will leave little in it to be desired. In any event, present profits in the industry suggest a propitious time for metallurgical studies for improved methods that would be impracticable in normal times.

In addition to experiments reported to the Survey and noted in the reviews by States, it is known that trials have been made in 1915 of rotary furnaces of undesignated type and of Herreshoff roasting furnaces, in both cases with sufficient encouragement to continue experiments.

Whatever furnace may be used, problems of dependable daily working capacity, of economy of labor and fuel, of prevention of leakage, of undue depreciation of plant, and particularly of efficient condensation, are of first rank in consideration.

As the Johnson-McKay type of retort plant is so largely used in development of prospects, the following data from a letter to the Survey from the Joshua Hendy Iron Works, San Francisco, makers of this retort plant, are given as of general interest to the industry:

The Johnson & McKay quicksilver furnace consists of a series of retort pipes set up in brickwork, complete with covers, condenser pipes, etc. The retort pipes are furnished either 10-inch or 12-inch diameter, the larger size being preferable. The usual furnace consists of a battery of twelve 12-inch pipes, but a less number of pipes may be installed, if desired.

With a 12-pipe retort, where the duration of the roasting period for each charge of ore would take 12 hours, the operation of this furnace is continuous, in that one pipe is unloaded and recharged with ore every hour. When the pipes are sufficiently heated, they are successively charged with ore at hourly intervals, so that at the end of 12 hours the charge in the first pipe will have roasted for that length of time, and the last pipe will have been charged. The first pipe is then ready for unloading and recharging. At the end of the next hour the second pipe is unloaded and recharged, and this operation is continued indefinitely. This cycle of operation is based, however, on a 12-hour roasting period for each charge of ore; but that the length of the roasting period may vary is obvious, this being dependent on the character of the ore, the intensity of heat maintained in the furnace, the experience of the attendant, etc.

It will be understood also that the capacity of these furnaces varies. We will say, however, that the capacity of a twelve 12-inch pipe retort is usually rated at 5 tons per 24 hours, but some users of this same size of furnace have reported a daily capacity of 7 tons. Using wood for fuel, the consumption is about $1\frac{1}{4}$ to $1\frac{1}{2}$ cords per day.

DEPOSITS, ORES, AND GANGUES.

In the Geological Survey's report on quicksilver for 1911 the writer gave a summary of deposits, ores, and gangues, mainly for the benefit of those not needing numerous details—miners, prospectors, and others—to whom the literature on the subject may not be readily accessible. Prospectors have apparently found the information of use. Copies of that report are still available for free distribution by the Survey.

RESOURCES, OCCURRENCES, AND DEVELOPMENTS, BY STATES.

ALASKA.

The presence of native quicksilver and cinnabar has been known in Alaska for many years and references to it have been made in these and other Survey reports. Two prospects in the Kuskokwim region visited by Smith and Maddren, of the Alaskan division of the Survey, in 1914, have recently been described by them.[1] The occurrence of cinnabar with stibnite in this and other localities in Alaska is further discussed by Brooks.[2] There has been only a nominal output of quicksilver for local use from the Alaskan deposits and the prospects require further development before their value can be appraised.

ARIZONA.

There was a nominal output of quicksilver in Arizona in 1915, all from the Mazatzal Range, in Maricopa County. The total production to date from this State has been extremely small, as the development work is still largely in the prospect stage.

[1] Smith, P. S., and Maddren, A. G., Quicksilver deposits of the Kuskokwim region: U. S. Geol. Survey Bull. 622, pp. 272–291, 1915.

[2] Brooks, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, pp. 12, 45–46, 49, 1916.

Gila and Maricopa counties.—In the Mazatzal Range, on the northeastern boundary between Maricopa and Gila counties, there has been continued prospecting and development since 1912. The ore is cinnabar associated with quartz in the schists. The locality was visited and described by Ransome.[1] From the Gila County group of claims H. H. Bowman and William Reynolds got out a small quantity of ore in development work. On the Lost Packer group, in Maricopa County, a considerable showing of ore averaging one-half of 1 per cent quicksilver is reported exposed. A reduction plant was in contemplation for these claims in 1916. A 1-pipe retort, it is reported, has been in operation by Christopher Martin on ore yielding about 5 per cent from the L and N claims. The Sunflower Co. made no output of metal but mined ore from an open cut. The Arizona group is being developed by a crosscut by Wheeler McDivett. The Tatum group had only assessment work done in 1915.

Pima County.—At the Roadside mine, in Pima County, Courtenay DeKalb, consulting engineer, reported to the Survey the presence of cinnabar, native mercury, and mercurial tetrahedrite in copper-silver ore.

Yavapai County.—In the Skull Valley district, 41 miles southwest of Prescott, considerable interest was reported in quicksilver prospects. The occurrence of quicksilver in this region was mentioned by Blake.[2]

Yuma County.—No production was reported for 1915 by the Cinnabar Development Co. from its claims in the Quartzsite district. The mine was shut down.

CALIFORNIA.

The quicksilver industry was everywhere active in California during 1915. Stimulation by high prices led to renewed prospecting and development, additional reduction capacity, and experimentation with additional means for better extraction.

The production of quicksilver in California in 1915 was 14,283 flasks, valued at $1,174,881, of which 13,123 flasks were produced from furnaces and 1,160 flasks from retorts. The output in 1914 was 11,303 flasks, valued at $554,414, and the gain for 1915 was therefore 26 per cent in quantity and 112 per cent in value. Whereas the production of 1914 was the smallest in quantity and value since 1860 and the output of 1915 was, next to that of 1914, the smallest in quantity, it was the highest in value since 1904 and highest in average price per flask since 1875. In 1915 and 1914 California furnished 68 per cent of the total domestic output of quicksilver against 77 per cent in 1913, 82 per cent in 1912, and 89 per cent in 1911.

In the following table giving the best available data for the output of quicksilver in California from 1850, the year of earliest production, to date, the flask is taken at 76½ pounds net of quicksilver until June, 1904, and at 75 pounds net since that date.

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[1] Ransome, F. L., Quicksilver deposits of the Mazatzal Range, Ariz.: U. S. Geol. Survey Bull. 620, pp. 111–128, 1915.

[2] Blake, W. P., Minerals of Arizona, their occurrence and association; a report to the Governor of Arizona, p. 15, Tucson, 1909.

Quicksilver produced in California, 1850–1915.

Year.	Flasks.	Price per flask.	Value.	Year.	Flasks.	Price per flask.	Value.
1850	7,723	$99.45	$768,052	1884	31,913	$30.50	$973,347
1851	27,779	66.93	1,859,248	1885	32,073	30.75	986,245
1852	20,000	58.33	1,166,600	1886	29,981	35.50	1,064,325
1853	22,284	55.45	1,235,648	1887	33,760	42.375	1,430,580
1854	30,004	55.45	1,663,722	1888	33,250	42.50	1,370,625
1855	33,000	53.55	1,767,150	1889	26,464	45.00	1,190,880
1856	30,000	51.65	1,549,500	1890	22,926	52.50	1,203,615
1857	28,204	48.73	1,374,381	1891	22,904	45.25	1,036,406
1858	31,000	47.83	1,482,730	1892	27,993	40.71	1,139,595
1859	13,000	63.13	820,690	1893	30,164	36.75	1,108,527
1860	10,000	53.55	535,500	1894	30,416	30.70	933,771
1861	35,000	42.05	1,471,750	1895	36,067	37.04	1,335,922
1862	42,000	36.35	1,526,700	1896	30,765	34.96	1,075,544
1863	40,531	42.08	1,705,544	1897	26,691	37.28	995,040
1864	47,489	45.90	2,179,745	1898	31,092	38.23	1,188,647
1865	53,000	45.90	2,432,700	1899	29,454	47.70	1,404,956
1866	46,550	53.13	2,473,202	1900	26,317	44.94	1,182,686
1867	47,000	45.90	2,157,300	1901	26,720	48.46	1,294,851
1868	47,728	45.90	2,190,715	1902	28,972	43.20	1,251,590
1869	33,811	45.90	1,551,925	1903	30,526	45.29	1,382,523
1870	30,077	57.38	1,725,818	1904	29,217	43.50	1,270,940
1871	31,686	63.10	1,999,387	1905	24,635	36.22	892,280
1872	31,621	65.93	2,084,773	1906	20,310	39.50	802,245
1873	27,642	80.33	2,220,482	1907	17,431	39.60	690,268
1874	27,756	105.18	2,919,376	1908	16,984	44.17	750,183
1875	50,250	84.15	4,228,538	1909	16,078	45.45	730,745
1876	72,716	44.00	3,199,504	1910	17,211	46.51	800,484
1877	79,395	37.30	2,961,434	1911	18,860	46.01	867,749
1878	63,880	32.90	2,101,652	1912	20,524	42.05	863,034
1879	73,684	29.85	2,199,467	1913	15,591	40.23	627,228
1880	59,926	31.00	1,857,706	1914	11,303	49.05	554,414
1881	60,851	29.83	1,815,185	1915	14,283	82.25	1,174,881
1882	52,732	28.23	1,488,624				
1883	46,725	28.75	1,343,344		2,164,919		97,632,218

San Benito County, in which is the New Idria mine (the largest producer in all the Americas), led as usual in output of quicksilver; it was followed in order by Santa Clara County (with the greatest total output to date), in which are the important New Almaden and New Guadalupe mines; and by San Luis Obispo County, in which are the Oceanic and Cambria mines as principal producers.

There were 32 producing mines and prospects in California in 1915, against 20 in 1914. Altogether 133,920 tons of ore were produced, against 95,348 tons in 1914; and 129,521 tons of new and old ore and other material were treated, against 101,553 tons in 1914. Of the ore treated, the furnaces received 127,251 tons in 1915, against 97,142 tons in 1914, and the retorts treated 2,270 tons, against 4,411 tons in 1914.

Quicksilver produced in California, 1915, by counties.

County.	Quantity (flasks of 75 pounds).	Value.	County.	Quantity (flasks of 75 pounds).	Value.
Lake	386	$31,232	Sonoma	127	$12,574
Napa	492	52,248	Other counties [a]	1,177	102,640
San Benito	6,331	456,889		14,283	1,174,881
San Luis Obispo	1,462	131,650			
Santa Clara	4,308	387,648			

[a] Includes Fresno, Kings, Monterey, Santa Barbara, Solano, and Yolo, with one producer each.

Colusa County.—The Manzanita mine, purchased by J. W. Cuthbert, of Wilbur Springs, made no output in 1915, but negotiations were underway for development for production in 1916. The Wilbur

Hill, Elgin, Empire, and Central mines were also being prepared for production.

Fresno County.—The Mercy mine made but a small production in 1915, owing to litigation. It has reverted to the original owners with prospect of resumption of operations.

Kings County.—The Segregation claim, operated by the Kings Quicksilver Mining Co., was productive in 1915 from the 10-ton Scott furnace recently completed. The Lookout and Summit claims have been further prospected.

Lake County.—The old Sulphur Banks, Helen, and Wall Street mines were all productive in 1915. Although the Great Western and Mirabel mines have been closed, high prices led to working over old dumps and other material and each property made a small output, though no new ore was mined or treated in 1915. At the Wall Street a small furnace has been under construction and other equipment was added. At the Helen, in recent years the largest producer in the county, a 25-horsepower oil engine and compressor were added and considerable development work was done. Prospects were bright for increased output for 1916. At the Sulphur Banks mine, closed for many years, no new mining was done, but a notable output was made from treatment of old dumps and clean-ups of furnace material in D retort. At the Abbott mine, formerly a large producer in the Sulphur Creek district, a force of men was employed to put the plant in operation and production was expected for 1916.

Monterey County.—At the Patriquin mine, near Parkfield, a 12-pipe retort was running in 1915, treating 1½ tons of ore each 24 hours and making a considerable output. The ore was reported to run from 4 to 5 per cent recovered metal and additional plant equipment was in prospect.

Napa County.—The Knoxville mine was not operated in 1915, but production was made by retorting ore taken out in 1913–14. At the Oat Hill mine experiments in concentrating old dumps were continued and production by retorting these concentrates was maintained throughout the year. At the Ætna mine production resulted from retorting concentrates and crude ore. A 40-ton Scott furnace is being prepared to treat a large quantity of 0.5 per cent ore on the dumps and an extensive ore body reported in the mine. The Twin Peaks property was operated by a small force and output was made from retorts. The old Bella Union and Oakville mines were under development in 1915 and a 50-ton concentrating plant was under construction. The La Joya property of the same company is 4 miles southwest of the Bella Union.

San Benito County.—The Alpine mine was equipped with a 25-ton Scott furnace early in 1916 and gave promise of considerable production in the future, but made no output in 1915. The Archer mine was relocated and assessment work was done, but it did not produce in 1915. The Aurora mine, also nonproductive, was under development; it is equipped with a 50-ton Hagerman rotary furnace and a small retort plant used in prospecting. At the Esmeralda (Monterey) also development work was reported. At the Florence-Mac a Johnson-McKay 12-pipe retort was completed and a small output was made from ore obtained during development work. At the Wonder mine also development work led to a small output from the 6-pipe retort plant, and the Hernandez produced from the

4-pipe retort plant. The Tirado prospect was equipped with a 4-D-retort plant and began producing early in 1916.

The New Idra mine continued to be the most important producer in America. The property is equipped with three Scott furnaces, each with a capacity of 80 tons of ore a day. The usual large amount of prospecting and development work was done and prospects for good ore supplies were bright for 1916. The tunnel into the San Carlos ore body was completed and ore was first taken from that property in December. In the first half of the year two furnaces were in operation and in the second half all three furnaces were operated. According to the published report of the company, 66,538 tons of ore, producing 6,250 flasks of quicksilver, were reduced in 1915, against 62,578 tons, yielding 6,550 flasks, in 1914. The average price received in 1915 was about $74 per flask. Two dividends, amounting in all to $150,000, were paid. Decrease in tenor of ore continued in 1915, but new ore supplies made available in 1916 may prevent further decrease.

San Luis Obispo County.—The Libertad mine, in the Adelaide district, made a small output from ore treated in a 12-pipe Johnson-McKay retort plant. A furnace was planned for this property, which, with others in the district, was reported to show promising prospects from development work done. The Cambria mine, in the San Simeon district, was again under active development and made a considerable output of ore and metal. Prospects were reported good for increased output in 1916. The Doty prospect was further developed, but it lacks a suitable reduction plant. The Karl mine produced from operation of the 13-pipe retort. The Oceanic mine again made a notable output of ore and metal and developed a large quantity of low-grade ore suitable for the 50-ton Scott furnace. The Klau, Josephine, and Capitola properties were not productive in 1915.

Santa Barbara County.—The old Los Prietos mine was actively developed and made a small output in 1915. Two 10-pipe retorts of the Johnson-McKay type were installed and prospects were for an increased output in 1916. The Santa Ynez and Acachuma mines were also reported under development. High prices for quicksilver increased interest in the Santa Ynez district in 1915.

Santa Clara County.—The New Discovery Quicksilver Co. operated a 24-pipe retort plant of the Johnson-McKay type at the old Hillsdale property during the latter part of 1915, but closed down in December after mining and treating a small quantity of ore in an experimental way.

At the New Guadalupe mine the usual large output of ore was mined and treated, resulting in the second largest production in California. This property has long been an important producer and, according to reports, the holdings have recently been further strengthened and new prospecting and development have been under way. At the New Almaden two new prospects were under development in 1915 and important production continued from the old dumps. The San Juan, near the Hillsdale, was not in operation in 1915.

Siskiyou County.—There was no development or production reported from Siskiyou County for 1915, but early in 1916, after preliminary prospecting, a most interesting experiment in sluicing surface material carrying cinnabar was begun under William Forstner,

consulting engineer. In the country rock, principally hornblende gneiss, small seams occur, the walls of which are coated with cinnabar, but no well-defined ledge has been found. The weathered surface material and detritus both carry cinnabar, some crystals being half an inch long and more or less water-worn. A string of 12 or 16 sluice boxes has been utilized, but most of the cinnabar is saved in the first two boxes. The material is to be treated in a Johnson-McKay 12-pipe retort. The region has furnished fine crystals of cinnabar in the past, some of them so pure they brought a high price to Chinese, who ground them fine for sale as vermilion.

Solano County.—A considerable quantity of ore was mined and treated in the old 15-ton Neat coarse-ore furnace at the St. Johns mine in 1915, resulting in notable output of metal. A new 15-ton Scott fine-ore furnace was under construction for completion in 1916. This will treat fine ore not suitable for the old plant and the output should be considerably increased.

Sonoma County.—The Eureka mine was under development, with prospects for production in 1916. The Culver-Baer made a small output of metal and was being retimbered and otherwise prepared for active operation in 1916. The plant includes a 16-ton coarse-ore furnace and a 24-ton fine-ore Scott furnace. High prices for metal led to reopening of the Great Eastern mine in July and a small output was made from the 15-ton Scott furnace. At the Cloverdale operations were on a smaller scale than usual, but increased production was expected for 1916. The Socrates mine, closed down for years, was given much attention in 1915 and under new ownership was expected to have active development in 1916. The plant includes a 50-ton Scott furnace.

Stanislaus County.—Development work only was reported from the Newhall property in 1915. At the Phoenix the repair work on the mine timbering and on the 40-ton Scott furnace was completed late in the year, and production of metal began in December.

Trinity County.—No production or other operations were reported for 1915 from either the Trinity or the Integral mines.

Yolo County.—At the Reed property there was again a small production from retorts operating on old furnace material.

IDAHO.

No production of quicksilver was reported from Idaho up to the end of 1915. The occurrences of cinnabar in the State were described in the Survey report for 1911.

In the early part of 1916 James Ackriell, of Black Pine, Cassia County, Idaho, reported the discovery of a cinnabar deposit from which one assay gave 2 per cent quicksilver, 2 per cent copper, and 5 ounces per ton of silver. The gangue was reported to be grayish-white quartz with some barite. Little development work had been done at the time of writing, but the outcrops and the preliminary work apparently indicated a lode of considerable extent. The ore may prove to be a surface alteration product of schwatzite, the tetrahedrite of mercury, and therefore should be developed in depth before an extensive plant for quicksilver reduction planned.

NEVADA.

The production of quicksilver in Nevada in 1915 was 2,327 flasks, valued at $209,901, against 2,089 flasks, valued at $102,465, in 1914. Four producers reported in 1915 against 7 in 1914, and 21,975 tons of ore were treated, yielding an average of 0.4 per cent of metal, or 7.9 pounds per ton.

Humboldt County.—The Goldbanks mine did not produce in 1915, but construction of a 50-ton Herreshoff furnace was underway for completion early in 1916. At the Nevada-Almaden mine development work only was done. At the Dixie mine, which is equipped with a 3-pipe retort and a 25-ton concentrating plant (which produced last in 1912), operations were carried on leading to production in 1916. The ore is found in broken masses with a gangue along a fault. At the Ruby assessment work only was done. At the Antelope Springs claim of J. Sweet a 12-pipe retort was operated and made a considerable production in 1915. Frank J. Davis has reported the occurrence of cinnabar in blue limestone at Antelope Springs.

Mineral County.—Near Mina the various quicksilver prospects were under further development in 1915. On the Lost Steers group a small quantity of ore was mined and a D retort was erected for production in 1916. On the Cinnabar King group a small retort plant was in course of construction. The district was studied by Adolph Knopf,[1] of the United States Geological Survey, in 1914.

Nye County.—In the Fluorine district, on Bare Mountain, a small output was made from the Telluride group, the result of experiments in concentrating low-grade ores on Wilfley tables and treating the concentrate in a D retort. The experiments were reported sufficiently encouraging to justify further efforts of concentration. Development work only was reported at the Mammoth No. 5 prospect. The quicksilver deposits were visited and described by Knopf.[2]

In the Ione district the Mercury mine was actively operated in the last half of the year and made a considerable output of metal from the 25-ton Scott furnace. The Nevada Cinnabar mine was a large producer throughout the year from ore treated in the 50-ton Scott furnace. Mining was by open-cut, glory-hole, and prospect tunnels.

OREGON.

Deposits of cinnabar have been known in Oregon for many years, and there has been some production from time to time. The occurrences were briefly outlined in the Survey report on quicksilver in Mineral Resources for 1911. In more recent years, up to 1915, there were no production or other operations reported to the Survey, but in 1915 the high prices prevailing for quicksilver led to renewed prospecting and development.

Crook County.—On Lookout Mountain, near Howard, the Central Mining Co. of Oregon was developing a property in 1915 and made a small output from ore treated in a Johnson-McKay pipe retort.

Grant County.—Near Canyon City a quicksilver deposit known many years ago was relocated by Ralph N. Curl on Cinnabar Mountain, according to press reports, and will be put in shape for development.

[1] Knopf, Adolph, Some cinnabar deposits in western Nevada: U. S. Geol. Survey Bull. 620, pp. 59–62, 1915.
[2] Knopf, Adolph, op. cit. pp. 62–67.

Lane County.—The Black Butte mine, south of Cottage Grove, was not operated in 1915. The property has been extensively developed and is equipped with a 40-ton remodeled Scott furnace; it produced in a small way some years ago.

Jackson County.—Much interest has lately been shown in quicksilver deposits in the Meadows district on Evans Creek, near Beagle and about 12 miles northeast of Gold Hill. The Mountain King property was developed by a 700-foot tunnel at the close of 1915 and has since changed hands for a large sum, according to reports. Free quicksilver is found in the mine, as well as cinnabar. A 6-pipe retort has been installed and preparations have been made for larger operations. A number of other claims have been located and considerable preliminary work was done on some of them in 1915.

TEXAS.

The quicksilver production in Texas from 1911 to 1915, inclusive, came from a single mine and figures for output can not be given. Prior to that time the production was as shown in the following table:

Quicksilver produced in Texas, 1899–1910, in flasks.[1]

1899	1,000	1904	5,336	1909	4,188
1900	1,800	1905	4,723	1910	3,320
1901	2,932	1906	4,761		
1902	5,319	1907	3,686		44,476
1903	5,029	1908	2,382		

Brewster County.—Quicksilver-mining operations in Texas have been confined almost wholly to the Terlingua district, on the Mexican border in the southern part of Brewster County. The district and operations have been briefly described in previous Survey reports, and references to the literature have been given in recent volumes of Mineral Resources.

The only production in recent years has been from the Chisos mine, which has been continuously under active development since it was first opened and now ranks as the second largest producer in the United States. It is equipped with a 20-ton Scott furnace and extensive experiments have been under way to increase extraction by improvement of metallurgical methods. The Big Bend mine was reopened in the latter part of 1915, and it was intended to begin operations of the 50-ton furnace early in 1916. The old Marfa-Mariposa mine, now operated by the Mariposa Mining Co., pioneer producer of the district, was not operated in 1915, but has since been reopened under its former efficient management. Old dumps will be worked over under the stimulus of present high prices and prospecting and development of new ore bodies will be renewed. The 20-ton Scott furnace has been worked at low cost in the past. This mine has produced rich ores in former years, including the secondary oxychlorides of interest to mineralogists.

[1] Flasks, 76½ pounds net before June 1, 1904; 75 pounds since June 1, 1904.

UTAH.

There has been no production of quicksilver in Utah since the closing of the Sacramento gold mines, at Mercur, where a considerable output had been made as a by-product. In 1914, however, H. L. Stratton, a prospector, located the Marietta claim, in Willard County, upon which he reported a 4-foot vein in which a promising cinnabar content was shown at a depth of 6 feet.

The interesting deposits of sulphoselenides of mercury near Marysvale, referred to in previous Survey reports, have not produced since they were closed down years ago as worked out.

WASHINGTON.

Occurrences of cinnabar in Washington were briefly summarized in the Survey quicksilver report in Mineral Resources for 1911.

Chelan County.—No operations were reported from the Leavenworth prospect, near Orondo, in 1915.

Lewis County.—No operations were reported from Lewis County for 1915, but early in 1916 there was active prospecting and development of cinnabar deposits, 2 miles from Morton, on the western flank of Mount Ranier. A 12-pipe Johnson-McKay retort plant has since been installed and successfully operated, according to latest reports.

WORLD'S PRODUCTION.

In the following table are given the best figures available for the world's production of quicksilver in recent years, calculated to flasks of 75 pounds net. For foreign countries the figures are taken mainly from the twentieth annual issue of "Comparative statistics," compiled by the Metallgesellschaft, Metallurgischen Gesellschaft A. G., and the Berg- und Metallbank Aktiengesellschaft, of Frankfort-on-the-Main, Germany, courteously furnished to the Survey by the American Metal Co. For certain data, as indicated, the writer is indebted to The Mineral Industry and other sources. A full statement of the world's output to date can not be expected to be available during the progress of the war in Europe.

World's production of quicksilver, 1906–1915, in flasks of 75 pounds each.

Country.	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
United States	26,083	21,554	19,752	21,075	20,601	21,256	25,064	20,213	16,548	21,033
Austria-Hungary	16,961	16,667	18,519	17,902	20,400	23,310	23,016	[a]26,720	[c]	[c]
Italy	12,287	12,424	19,989	22,664	26,279	27,367	28,983	[a]29,513	[b]31,541	[c]
Russia	6,173	3,821	1,440	206	118	[c]	[c]	[c]	[c]	[c]
Spain	46,062	35,627	31,394	40,947	32,746	[d]43,681	[d]43,799	[d]43,799	[c]	[c]
Mexico and other countries	[e]5,879	[e]5,879	[e]5,879	[e]4,409	[e]4,409	[e]4,409	[e]4,409	[e]4,409	[c]	[c]
	113,445	95,982	96,973	107,203	104,553	120,023	125,271	124,654	.....	.....

[a] The Mineral Industry.
[b] Riv. servizio min., Rome, 1914.
[c] Statistics not available.
[d] Export figures only.
[e] Estimated.

The general increase of world output in the period for which complete figures are available had a direct bearing on the domestic industry, for the total production has been in excess of the world's

demands and any temporary improvement in prices in this country has been checked by importations from surplus foreign supplies produced at low cost. On the outbreak of the war the Austrian supplies were cut off, and Spanish supplies, controlled mainly in London, were held under embargo against export to any but allied countries. Some imports have been received from Italy under contracts made prior to the war, and additional supplies have been received more recently from London to assist munitions contractors in fulfilling their obligations to the allies. According to Pickering [1] the imports of quicksilver into Great Britain for 1915 were 40,579 bottles, against 37,568 in 1914, and the exports were 13,020 bottles, against 22,975 bottles in 1914. The estimated consumption in the United Kingdom was 15,000 bottles.

The production of Spain and of Italy has been reported increasing since the outbreak of the war and the establishment of higher London prices. The famous Santa Barbara deposits of Huancavelica, Peru, have passed into new hands and may be reopened.[2] The production of quicksilver from treatment of low-grade ores at Punitaqui, Chile, has been reported by Lamb.[3]

Deposits of cinnabar have been noted in Mexico, but there have been no reports of recent operations known to the Survey. The Terlingua field, of Brewster County, Tex., is reported to extend for a considerable distance into Mexico, with promise of workable ore bodies similar to those on the Texas side of the border.

IMPORTS AND EXPORTS.[4]

The import tariff on quicksilver, from 1890 to 1895, was 10 cents per pound; from 1895 to 1913 it was 7 cents; and the Underwood tariff bill, enacted in 1913 and now in force, made the tariff 10 per cent ad valorem, which, for the whole year, would be, roughly, as follows:

Tariff rate per pound on quicksilver, based on average prices in New York and London, 1913–1915.

Year.	New York.	London.
1913	$0.053	$0.048
1914	.064	.046
1915	.116	.096
Average	.078	.063

In the following tables are given imports of quicksilver for domestic consumption, in pounds, exports in flasks, and exports, by countries, in pounds. Although imports decreased in quantity from the high figures of 1914 they increased slightly in value, owing to prevailing high prices in 1915. Exports more than doubled in quantity and more than trebled in value, and may again reach the higher figures in quantity preceding 1910.

[1] Pickering, A. H., Quicksilver in 1915: Min. Jour. (London), Jan. 15, 1916.
[2] Eng. and Min. Jour., Mar. 18, 1916.
[3] Lamb, M. R., Flotation for cinnabar: Min. and Sci. Press, July 1, 1916.
[4] Statistics of imports and exports have been compiled by J. A. Dorsey from records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Quicksilver imported and entered for consumption in the United States, 1906–1915.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1906	84	$50	1911	471,944	$251,386
1907	16,567	6,719	1912	82,706	39,920
1908	15,113	8,216	1913	171,653	75,361
1909	15,968	8,203	1914	614,869	271,984
1910	667	381	1915	421,884	282,752

Quicksilver exported from the United States, 1906–1915.

Year.	Quantity (flasks of 75 pounds).	Value.	Year.	Quantity (flasks of 75 pounds).	Value.
1906	6,456	$243,914	1911	291	$13,995
1907	5,132	192,094	1912	310	13,360
1908	2,996	124,960	1913	1,140	43,574
1909	6,802	266,243	1914	1,446	70,753
1910	1,923	91,077	1915	3,372	225,509

Domestic quicksilver exported from the United States, 1913–1915, by countries.

Country.	1913		1914		1915	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
Europe:						
England	215	$140			10,369	$7,498
France			44,350	$31,070	71,089	70,944
Greece					550	436
Netherlands			383	230	2,610	2,180
Norway					600	375
Sweden					13,200	15,840
North America:						
Canada	80,162	40,362	23,950	15,371	20,979	21,541
Newfoundland					310	286
Mexico	1,500	821	2,086	1,054	3,065	3,111
Central America:						
Costa Rica	306	165	360	236	490	461
Honduras	75	43	1,363	897	113	117
Nicaragua	750	483			1,293	1,053
Panama	103	74				
Salvador	675	368	225	115	703	657
Outlying Islands:						
Barbados					5	6
Cuba			225	175	1,093	1,202
Dominican Republic	89	41	18	13		
South America:						
Argentina					1,351	1,302
Bolivia	92	53				
Brazil					1,338	1,399
Chile			1,870	1,250	3,750	4,000
Colombia	1,090	738	1,952	1,309	1,307	1,351
Ecuador					75	94
Guiana—						
British					616	554
French					2,908	1,925
Peru					1,422	1,312
Venezuela	89	67	1,644	1,033	4,106	3,890
Africa:						
British South Africa			30,000	18,000	37,920	26,000
Portuguese South Africa					880	990
Asia:						
Chosen (Korea)					5,250	6,425
Hongkong	150	84			30,000	23,930
Japan					26,655	20,662
Oceania:						
Australia					7,630	4,745
Dutch East Indies					225	270
Philippines	225	135			920	953
	85,521	43,574	108,426	70,753	252,852	225,509

PRICES.

Prices of quicksilver declined materially in 1912, 1913, and during the first part of 1914, and the decline seriously affected the prosperity of the industry. As shown by the tables below, however, the prices have risen greatly since the outbreak of the European war, and domestic producers are now in a position to make a profit.

The prices given in the following table for New York and London are taken from the Engineering and Mining Journal. As the primary domestic market is San Francisco, the price there is averaged from the weekly and monthly market quotations published in the Mining and Scientific Press. The prices received by producers in individual sales varied, of course, from the market prices as published, which are annual averages of generally prevailing quotations.

Average yearly prices of quicksilver in the United States and London from 1907 to 1915, inclusive.[a]

[Per flask of 75 pounds.]

Year.	San Francisco (domestic).	New York.	London.	Year.	San Francisco (domestic).	New York.	London.
1907	$39.60	$41.50	.....	1912	$42.05	$42.46	$39.61
1908	44.17	44.84	.....	1913	[b] 40.23	39.54	35.91
1909	45.45	46.30	.....	1914	[b] 49.05	48.31	[c] 34.80
1910	46.51	47.06	.....	1915	[b] 85.80	87.01	71.78
1911	46.01	46.54	.....				

[a] From Eng. and Min. Jour., New York.
[b] From Min. and Sci. Press, San Francisco.
[c] January–July, inclusive.

The following table shows the average monthly quotations for 1914, 1915, and part of 1916 for San Francisco (domestic), as published in the Mining and Scientific Press:

Prices of domestic quicksilver at San Francisco, 1914–1916.

[Per flask of 75 pounds.]

Month.	1914	1915	1916	Month.	1914	1915	1916
January	$39.25	$51.90	$222.00	July	$37.50	$95.00	$81.20
February	39.00	60.00	295.00	August	80.00	93.75	.....
March	39.00	78.00	219.00	September	[a] 76.25	91.00	.....
April	38.90	77.50	141.60	October	53.00	92.90	.....
May	39.00	75.00	90.00	November	55.00	101.50	.....
June	38.60	90.00	74.70	December	53.10	123.00	.....

[a] Market fluctuated greatly at outbreak of European war.—H. D. McC.

LITERATURE.

Fairly complete lists of references to the literature on quicksilver for the North American continent have been given in previous volumes of Mineral Resources, especially for 1910 and 1911, and a new and complete list is planned for the report for 1916.

IRON ORE, PIG IRON, AND STEEL.[1]

By Ernest F. Burchard.

INTRODUCTION.

Conditions in the iron industry at the beginning and at the close of the year 1915 presented a strong contrast. At the close of 1914 it was generally believed by persons in the trade that the depression had reached its limit and that a reaction must soon begin. Aside from this feeling, however, the prospects at the beginning of 1915 seemed fairer than they had been for several months, although it was feared that many restraining influences would likely continue to operate well into the year.

The beginning of 1915 found the lower Lake docks and the blast furnaces dependent on Lake ores well stocked with ore, for which there was little demand. Precedents, however, pointed to an increase in output of ore in 1915, for, except in a few years, there has been a larger output of iron ore in each year that followed a year of declining production. The iron-mining season began auspiciously for the Lake Superior district, for in May, 1915, the shipments were 5,012,359 gross tons, compared with 3,852,063 gross tons in May, 1914, an increase of 1,160,296 tons, or more than 30 per cent. It was not, however, until the middle of the year 1915 had passed that a great demand for ore arose, but it met with a ready response, as is indicated by the large shipments down the Lakes from July to November, inclusive, which ceased only when the canals and rivers were closed by ice. In the South, also, business was quiet during the first half of the year, but later felt the influence of the extraordinary demand for iron and steel.

Many persons believe that a considerable impetus for the upward swing of the iron pendulum was imparted by European war orders, but there were also many indications of returning activity in most other industries, such as resumption of construction work, extensions of manufactories, and increase of prices of practically all commodities; in short, the domestic commerce of the United States seemed generally to revive in the last half of 1915.

One American industry which requires large quantities of iron and steel and for which the future outlook brightened considerably during 1915 is shipbuilding. The destruction of merchant ships in the war and the interning of ships of belligerent countries in neutral ports, coupled with the difficulties of European builders in replacing them promptly, have caused a flood of orders to be poured into American shipyards. Better opportunities have also been opened

[1] The statistics in this chapter were compiled by Miss M. B. Clark.

for American foreign trade, for which there is a dearth of ships. The extraordinary demands for iron ore revealed a shortage of bulk Lake freighters, which will hardly be made up during the season of 1916. It is therefore probable that, with the work now in hand and in sight, American shipbuilders will have all the business they can handle for several years.

On January 6, 1916, the Survey's estimate of shipments of iron ore in 1915 was released to the press. This estimate was based on preliminary reports from the leading iron-mining companies in the principal iron-ore producing districts. The estimated shipments were within 0.9 per cent of the complete figures published herein.

The early part of 1916 shows a continuation of the highly prosperous conditions that prevailed during the last four or five months of 1915, and in fact the activity in iron and steel manufacture is even greater, presaging an enormous demand for iron ore for the mining and shipping season of 1916.

In this report new tables have been inserted showing monthly shipments of iron ore by the Lakes and the quantities and values of the exports of iron and steel. A bibliography of Federal and State publications on iron ore is given, the preceding one having been published in this chapter for 1913. A section on beneficiation of iron ores in the Lake Superior region has been contributed by specialists in this subject, Messrs. Edmund Newton and Harlan H. Bradt, of Duluth, Minn. This is a contribution for which the Survey is very grateful, as it comes at a time when interest in this practice is growing rapidly. It supplies valuable historical data, outlines the general principles underlying the treatment of the several varieties of Lake ores, and gives a list of important papers on the subject.

IRON ORE MINED AND SHIPPED IN 1915.

The iron ore mined in the United States in 1915 amounted to 55,526,490 gross tons, as compared with 41,439,761 gross tons mined in 1914, an increase of 14,086,729 gross tons, or 34 per cent. Beneficiated ore instead of crude ore mined is included if the ore is treated in any way. The quantity of iron ore shipped from the mines in the United States in 1915 amounted to 55,493,100 gross tons, valued at $101,288,984, as compared with 39,714,280 gross tons, valued at $71,905,079, shipped in 1914. This represents an increase in quantity of 15,778,820 gross tons, or 40 per cent, and in value of $29,383,905, or 41 per cent. The average price of ore per ton for the whole country in 1915 was $1.83, as compared with $1.81 in 1914. These quantities of ore, both mined and shipped, include the iron ore used for fluxing other metallic ores at smelters in the Western States, but the shipments do not include the iron ore sold for the manufacture of paint. The quantity of iron ore sold for the manufacture of paint in 1915 amounted to 20,760 gross tons, valued at $48,760. In Arkansas one producer shipped 10 tons of loadstone, averaging 72 per cent of metallic iron, which was sold at a high price. This shipment is not included in the tabulated statistics of iron ore. The ore reported as sold for fluxing other than in the manufacture of pig iron amounted to 17,213 gross tons, valued at $27,456, in 1915, as compared with 42,677 gross tons, valued at $114,985, in 1914. The domestic iron

ore actually sold for the manufacture of pig iron amounted in 1915 to 55,475,887 gross tons, valued at $101,261,528, as compared with 39,671,603 gross tons, valued at $71,790,094, in 1914.

A graphic comparison of the annual production of iron ore and its derived metals since 1870 is afforded by the curves shown in figure 4.

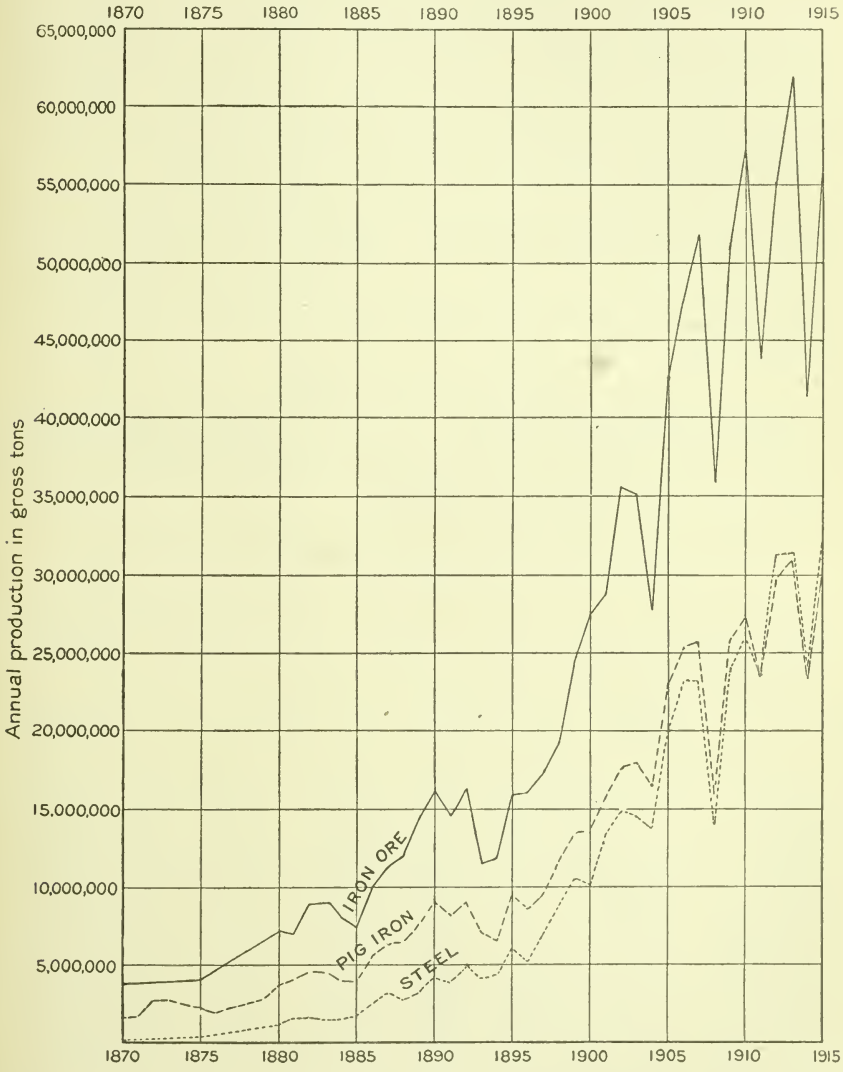

FIGURE 4.—Curves showing annual production of iron ore, pig iron, and steel in the United States, 1870 to 1915.

It must be borne in mind, however, that the figures for the three products are not strictly comparable, because considerable foreign iron ore enters into the production of pig iron and because a considerable quantity of scrap iron and steel enters into the production of new steel.

IRON ORE MINED AND SHIPPED, BY STATES.

Iron ore was mined in 23 States in 1915, as compared with 27 States in 1914. Of these States, Idaho, Nevada, and Utah produced ores for fluxing only; part of the production of California and Colorado was for smelter flux and part for pig iron and ferroalloys; the remaining States produced iron ore for blast-furnace use only, except small quantities for paint from Georgia, Michigan, New York, Pennsylvania, and Wisconsin. The rank of the five States producing the largest quantity of iron ore—Minnesota, Michigan, Alabama, Wisconsin, and New York—remained unchanged in 1915. New York was the only one of these States that produced less than 1,000,000 tons in 1915, and it did not fall far short of that mark.

The Minnesota iron ranges are producing more iron ore than all the rest of the States together, having furnished 60 per cent of the total for the United States in 1915. The Lake Superior district, comprising all the mines in Minnesota and Michigan and those in northern Wisconsin, mined 46,944,254 gross tons in 1915, or 85 per cent of the total production, as compared with 33,540,403 gross tons, or 81 per cent, in 1914.

IRON-ORE SHIPMENTS.

The following table, showing the iron ore shipped from the mines in 1914 and 1915, by States, is given precedence over the table showing the quantity mined because the table of shipments is the only one in which values are recorded:

Iron ore shipped from mines in the United States, 1914 and 1915, by States.

State.	1914		1915		Increase or decrease in 1915.		Percentage of increase or decrease in 1915.	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity.	Value.
Alabama	4,514,926	$5,727,619	5,134,955	$6,798,266	+ 620,029	+$1,070,647	+ 14	+ 19
California	1,282	5,128	646	2,584	− 636	− 2,544	− 50	− 50
Colorado	11,464	22,846	(a)	(a)	(a)	(a)	(a)	(a)
Georgia	66,222	119,363	101,719	186,083	+ 35,497	+ 66,720	+ 54	+ 56
Maryland	749	1,817	1,500	2,750	+ 751	+ 933	+100	+ 51
Michigan	8,533,280	18,722,358	13,664,437	28,218,627	+ 5,131,157	+ 9,496,269	+ 60	+ 51
Minnesota	23,298,547	40,628,771	32,545,236	57,742,643	+ 9,246,689	+17,113,872	+ 40	+ 42
Missouri	36,304	75,696	40,290	99,853	+ 3,986	+ 24,157	+ 11	+ 32
New Jersey	346,820	1,076,208	391,115	1,140,400	+ 44,295	+ 64,192	+ 13	+ 6
New Mexico	(a)	(a)	34,806	54,197	(a)	(a)	(a)	(a)
New York	640,252	1,992,892	931,745	2,797,270	+ 291,493	+ 804,378	+ 46	+ 40
Ohio	(a)	(a)	3,502	8,535	(a)	(a)	(a)	(a)
Pennsylvania	400,062	399,639	367,056	333,697	− 33,006	− 65,942	− 8	− 17
Tennessee	330,214	466,523	283,841	408,204	− 46,373	− 58,319	− 14	− 13
Virginia	346,382	719,415	334,424	696,920	− 11,958	− 22,495	− 3	− 3
Wisconsin	591,595	1,178,610	1,125,269	2,188,012	+ 533,674	+ 1,009,402	+ 90	+ 86
Other States b	596,181	768,194	532,559	610,943	− a 36,778	− a 117,365	− a 6	− a 15
	39,714,280	71,905,079	55,493,100	101,288,984	+15,778,820	+29,383,905	+ 40	+ 41

a Increases or decreases for Colorado, New Mexico, and Ohio included with those for "Other States."

b 1914: Connecticut, Idaho, Kentucky, Massachusetts, Mississippi, Montana, Nevada, New Mexico, North Carolina, Ohio, Utah, West Virginia, and Wyoming; 1915: Colorado, Connecticut, Idaho, Massachusetts, Nevada, North Carolina, Utah, and Wyoming.

IRON ORE MINED BY VARIETIES, BY STATES, AND BY MINING DISTRICTS.

Iron minerals comprise sulphides, oxides, carbonates, and silicates, of which only the oxides and the carbonates are used in the iron and steel industry, except a very small quantity of by-product from sulphide ores used in the manufacture of sulphuric acid. The ores of iron are generally classed under four heads:

Hematite, including all varieties of the anhydrous sesquioxide (Fe_2O_3—theoretical percentage of iron, 70). This is known locally as red hematite, specular ore, gray ore, fossil ore, and oolitic ore.

Brown ore, including hydrated sesquioxides, such as limonite, göthite, and turgite, or a mixture of these minerals ($Fe_2O_3nH_2O$—theoretical percentages of iron, 59.8–66.2). This is known locally as brown ore, brown hematite, bog ore, and limonite.

Magnetite, including magnetic oxides (Fe_3O_4—theoretical percentage of iron, 72.4). Magnetite is known generally as magnetic iron ore.

Iron carbonate, including carbonates of various types ($FeCO_3$—theoretical percentage of iron, 48.2). Iron carbonate is known locally as spathic iron ore, kidney ore, black-band ore, and siderite.

Hematite has always been predominant as an ore of iron, and in 1915 it constituted more than 94 per cent of the iron ore mined in the United States. Brown ore and magnetite are far below it in importance, having together furnished in 1915 less than 6 per cent of the total production of iron ore. The production of iron carbonate is insignificant in comparison with that of the other ores; in 1915 it constituted only about 0.006 per cent of the total.

Iron ore mined in the United States in 1914 and 1915, by States and varieties, in gross tons, with percentage of increase or decrease in 1915.

1914.

State.	Hematite.	Brown ore.	Magnetite.	Carbonate.	Total quantity.
Alabama	3,902,567	936,392	.....	.....	4,838,959
California	.....	.....	1,282	.....	1,282
Colorado	.....	10,464	.....	.....	10,464
Connecticut	.....	9,149	.....	.....	9,149
Georgia	11,836	55,886	.....	.....	67,722
Kentucky	21,400	.....	.....	.....	21,400
Maryland	.....	6,369	.....	.....	6,369
Massachusetts	.....	7,600	.....	.....	7,600
Michigan	10,796,200	.....	.....	.....	10,796,200
Minnesota	21,946,901	.....	.....	.....	21,946,901
Missouri	32,054	5,500	.....	.....	37,554
New Jersey	.....	.....	350,135	.....	350,135
New Mexico	.....	.....	81,980	.....	81,980
New York	49,704	.....	735,673	.....	785,377
North Carolina	.....	.....	57,667	.....	57,667
Ohio	.....	.....	.....	5,138	5,138
Pennsylvania	3,300	23,560	379,466	.....	406,326
Tennessee	202,330	123,884	4,000	.....	330,214
Virginia	66,904	311,616	.....	.....	378,520
West Virginia	.....	6,530	.....	.....	6,530
Wisconsin	886,512	.....	.....	.....	886,512
Wyoming	366,962	.....	.....	.....	366,962
Other States [a]	.....	40,800	.....	.....	40,800
	38,286,670	1,537,750	1,610,203	5,138	41,439,761

[a] Idaho, Mississippi, Montana, Nevada, and Utah.

Iron ore mined in the United States in 1914 and 1915, by States and varieties, in gross tons, with percentage of increase or decrease in 1915—Continued.

1915.

State.	Hematite.	Brown ore.	Magnetite.	Carbonate.	Total quantity.	Percentage of increase or decrease in 1915.
Alabama	4,374,309	935,045			5,309,354	+ 10
California			646		646	− 50
Georgia	16,505	99,196			115,701	+ 71
Maryland		5,500			5,500	− 14
Massachusetts		3,950			3,950	− 48
Michigan	12,514,516				12,514,516	+ 16
Minnesota	33,464,660				33,464,660	+ 52
Missouri	35,145	5,145			40,290	+ 7
Nevada		3,993			3,993	(*a*)
New Jersey			415,234		415,234	+ 19
New Mexico			34,806		34,806	− 58
New York	*b* 71,207	(*b*)	927,638		998,845	+ 27
North Carolina		857	65,596		66,453	+ 15
Ohio				3,455	3,455	− 33
Pennsylvania	(*c*)	*c* 22,552	340,757		363,309	− 11
Tennessee	181,509	100,469	2,207		284,185	− 14
Virginia	38,506	*d* 309,536	(*d*)		348,042	− 8
Wisconsin	1,095,388				1,095,388	+ 24
Wyoming	434,513				434,513	+ 18
Other States *e*		*d* 23,650	(*d*)		23,650	−*a* 69
	52,227,324	1,488,709	1,807,002	3,455	55,526,490	+ 34

a Less than three producers in Colorado and Connecticut in 1915 and in Nevada in 1914, and permission was not granted to publish State totals. Increases and decreases in 1915, therefore, included in "Other States."

b Brown ore included in hematite.

c Hematite included in brown ore.

d Magnetite included in brown ore.

e Colorado, Connecticut, Idaho, and Utah.

The principal iron-mining districts in the United States, except the Adirondack and the Birmingham districts, are interstate, and statistics of production by districts are of more general interest and importance than statistics by States. The Lake Superior district mined nearly 85 per cent of the total ore in 1915 and the Birmingham district about 8.5 per cent, or a little more than one-tenth as much as the Lake district. None of the other individual districts mined as much as 1,000,000 tons. The increase in production in 1915 was especially marked in the Lake Superior district, where it reached 40 per cent; the Adirondack and the Chattanooga districts each showed a large increase, namely, 28 and 25 per cent, respectively; but the combined output for a number of widely separated districts, including those in the Western States, showed decrease as compared with 1914.

Iron ore mined in the United States, by mining districts and varieties, in 1914 and 1915, in gross tons.

1914.

District.	Hematite.	Brown ore.	Magnetite.	Carbonate.	Total.
Lake Superior *a*	33,540,403				33,540,403
Birmingham	3,813,447	469,109			4,282,556
Chattanooga	280,146	151,860			432,006
Adirondack			544,724		544,724
Northern New Jersey and southeastern New York			541,084		541,084
Other districts	652,674	916,781	524,395	5,138	2,098,988
	38,286,670	1,537,750	1,610,203	5,138	41,439,761

a Includes only those mines in Wisconsin which are in the true Lake Superior district

Iron ore mined in the United States, by mining districts and varieties, in 1914 and 1915, in gross tons—Continued.

1915.

District.	Hematite.	Brown ore.	Magnetite.	Carbonate.	Total.	Percentage of increase or decrease in 1915.
Lake Superior [a]	46,944,254				46,944,254	+40
Birmingham	4,213,597	535,332			4,748,929	+11
Chattanooga	340,481	198,543			539,024	+25
Adirondack			699,213		699,213	+28
Northern New Jersey and southeastern New York		(b)	[b] 644,493		644,493	+19
Other districts	728,992	754,000	464,130	3,455	1,950,577	− 7
	52,227,324	1,488,709	1,807,002	3,455	55,526,490	+34

[a] Includes only those mines in Wisconsin which are in the true Lake Superior district.
[b] Brown ore included in magnetite.

These tables show that the greater part of the hematite comes from the Lake Superior district (Michigan, Minnesota, and Wisconsin) and Alabama, the bulk of the brown ore from the Appalachian States, and the magnetite from New York, New Jersey, and Pennsylvania. The iron carbonate is mined in Ohio. On a later page is given the production of the principal ranges in the Lake Superior district. It is well known that the bulk of the Lake Superior hematite is more or less hydrated and that many deposits include masses of brown ore having varying percentages of combined water. There is, however, a complete gradation from anhydrous hematite to limonite, and as there is no sharp dividing line and as also the greater part of the ore is nearer the anhydrous than the completely hydrated condition, the production of the hydrated ores is included in the production of hematite. Certain mines in northern Michigan produce an ore which is locally termed magnetite. It is a coarsely crystalline anhydrous ore consisting dominantly of hematite but having sufficient quantities of magnetite distributed through it to render the ore strongly magnetic. This magnetic ore is also included with hematite in the tables of production, both because it is not a true magnetite and because the quantity is not of sufficient importance to warrant making additional tables for magnetic ores.

The output of the magnetite mines in northern New Jersey and southeastern New York showed an increase of 19 per cent in 1915; the quantity of iron ore mined in the other (unspecified) districts showed a net decrease of 7 per cent.

TOTAL OUTPUT OF IRON ORE.

The following table shows the production of various types of iron ore in the United States as far as it has been recorded or estimated. The statistics from 1889 to the present were collected by the United States Geological Survey; those for 1880 were collected for the census report of that year; those for 1881 were estimated by I. L. Bell;[1] and those from 1882 to 1888, inclusive, were estimated by James M. Swank[2] from the pig iron produced. No figures can be

[1] Principles of the manufacture of iron and steel, p. 451, 1884.
[2] U. S. Geol. Survey Mineral Resources, 1882 to 1888.

obtained for the production of various classes of iron ores prior to 1889, except for the census year 1880. The figures for the years prior to 1880 were calculated from the pig iron produced, which included imported ore as well as domestic ore used.

Iron ore mined in the United States, 1810–1915, in gross tons.

Year.	Hematite.	Brown ore.	Magnetite.	Carbonate.	Total.
1810–1869					49,656,000
1870[a]–1879					44,570,527
1880	2,243,993	1,918,622	2,134,276	823,471	7,120,362
1881					7,119,643
1882					8,700,000
1883					8,800,000
1884					7,718,129
1885					7,600,000
1886					10,000,000
1887					11,300,000
1888					12,062,530
1889	9,056,288	2,523,087	2,506,415	432,251	14,518,041
1890	10,527,650	2,559,938	2,570,838	377,617	16,036,043
1891	9,327,398	2,757,564	2,317,108	189,108	14,591,178
1892	11,646,619	2,485,101	1,971,965	192,981	16,296,666
1893	8,272,637	1,849,272	1,330,886	134,834	11,587,629
1894	9,347,434	1,472,748	972,219	87,278	11,879,679
1895	12,513,995	2,102,358	1,268,222	73,039	15,957,614
1896	12,576,288	2,126,212	1,211,526	91,423	16,005,449
1897	14,413,318	1,961,954	1,059,479	83,295	17,518,046
1898	16,150,684	1,989,681	1,237,978	55,373	19,433,716
1899	20,004,399	2,869,785	1,727,430	81,559	24,683,173
1900	22,708,274	3,231,089	1,537,551	76,247	27,553,161
1901	24,006,025	3,016,715	1,813,076	51,663	28,887,479
1902	30,532,149	3,305,484	1,688,860	27,642	35,554,135
1903	30,328,654	3,080,399	1,575,422	34,833	35,019,308
1904	23,839,477	2,146,795	1,638,846	19,212	27,644,330
1905	37,567,055	2,546,662	2,390,417	21,999	42,526,133
1906	42,481,375	2,781,063	2,469,294	17,996	47,749,728
1907	46,060,486	2,957,477	2,679,067	23,589	51,720,619
1908	31,788,564	[b] 2,620,390	[b] 1,547,797	26,585	35,983,336
1909	46,208,640	[b] 2,839,265	[b] 2,229,839	16,527	51,294,271
1910	51,367,007	[b] 2,993,744	[b] 2,631,835	22,320	57,014,906
1911	39,626,224	2,032,094	2,202,527	15,707	43,876,552
1912	51,345,782	1,614,486	2,179,533	10,346	55,150,147
1913	57,933,251	1,682,063	2,357,274	7,849	61,980,437
1914	38,286,670	1,537,750	1,610,203	5,138	41,439,761
1915	52,227,324	1,488,709	1,807,002	3,455	55,526,490
					1,052,075,218

[a] Includes ore produced by owners of blast furnaces, estimated by census at 800,000 tons.
[b] Some brown ore included in magnetite.

PRINCIPAL IRON-ORE MINES.

In 1914 and 1915 there were 340 iron-ore mines active, compared with 411 mines in 1913, and 184 mines in 1915 produced more than 50,000 gross tons of iron ore each, compared with 164 mines in 1914. Of these 184 mines 7 produced more than 1,000,000 tons of iron ore each in 1915, 2 more than in 1914. First place in 1915 was held by the Mahoning mine, at Hibbing, Minn.; second place by the Hull-Rust mine adjoining the Mahoning; and third place by the Red Mountain group, near Bessemer, Ala. The production of these mines in 1915 was, respectively, 2,311,940 tons, 2,307,195 tons, and 2,138,015 tons of hematite, compared with 1,212,287 tons, 458,468 tons, and 2,008,465 tons in 1914. The Red Mountain group was the largest producer in 1914. The increase in production of the Hull-Rust is noteworthy—more than 400 per cent. From practically a condition of idleness the Morris mine within a year yielded 1,167,421 tons, and the Burt moved from forty-first place, with a production of about 250,000 tons, to seventh place, with a production of more

than 1,000,000 tons, in 1915. These records illustrate the rapidity with which the rate of output of mines in the Lake Superior district may be increased in response to demand. None but open-pit mines could be made to respond to such a degree. Six of the seven mines producing more than 1,000,000 tons in 1915 are in Minnesota.

The largest producer in Michigan in 1915 was the Norrie group, which reported having mined 897,484 gross tons of hematite. Permission has been granted to the Survey by the owners and operators of 167 of these large mines to publish their production, and these statistics are given in the following table:

Iron-ore mines of the United States that produced more than 50,000 gross tons each in 1915.

Rank.	Name of mine.	State.	Nearest town.	Variety of ore.	Quantity mined.
					Gross tons.
1	Mahoning	Minnesota	Hibbing	Hematite	2,311,940
2	Hull-Rust	do	do	do	2,307,195
3	Red Mountain group	Alabama	Bessemer	do	2,138,015
4	Canisteo	Minnesota	Coleraine	do	1,622,182
5	Sauntry-Alpena	do	Virginia	do	1,410,025
6	Morris	do	Hibbing	do	1,167,421
7	Burt	do	do	do	1,000,618
8	Hill	do	Marble	do	998,649
9	Leonard	do	Chisholm	do	902,959
10	Shenango	do	do	do	898,046
11	Norrie group	Michigan	Ironwood	do	897,484
12	Woodward 1, 2, and 3	Alabama	Lipscomb	do	880,737
13	Fayal	Minnesota	Eveleth	do	871,364
14	Holman	do	Taconite	do	845,898
15	Newport	Michigan	Ironwood	do	842,703
16	Adams	Minnesota	Eveleth	do	831,887
17	Leonidas	do	do	do	770,584
18	Sellers	do	Hibbing	do	721,908
19	Wakefield	Michigan	Wakefield	do	691,209
20	Missabe Mountain	Minnesota	Virginia	do	668,060
21	Susquehanna	do	Hibbing	do	630,885
22	Leetonia	do	do	do	628,540
23	Zenith	do	Ely	do	610,793
24	Commodore	do	Virginia	do	561,438
25	Harold	do	Hibbing	do	526,449
26	Spruce	do	Eveleth	do	501,840
27	Witherbee, Sherman & Co. (Inc.).	New York	Mineville	Magnetite	474,081
28	Kinney	Minnesota	Kinney	Hematite	471,521
29	Palms	Michigan	Bessemer	do	461,820
30	Sunrise	Wyoming	Sunrise	do	434,513
31	Caspian	Michigan	Palatka	do	420,465
32	Pioneer	Minnesota	Ely	do	413,086
33	Chisholm	do	Chisholm	do	403,881
34	Clark	do	do	do	387,067
35	Bristol	Michigan	Crystal Falls	do	386,800
36	Biwabik	Minnesota	Biwabik	do	382,985
37	Genoa	do	Gilbert	do	381,966
38	Graham	do	Mesaba	do	373,870
39	Utica	do	Hibbing	do	369,112
40	Montreal	Wisconsin	Montreal	do	360,486
41	Dean	Minnesota	Buhl	do	360,372
42	Chapin	Michigan	Iron Mountain	do	353,594
43	Colby	do	Bessemer	do	351,900
44	Queen group	do	Negaunee	do	343,993
45	Judd	Minnesota	Taconite	do	334,685
46	Armour No. 2	do	Crosby	do	333,856
47	Hawkins	do	Nashwauk	do	327,772
48	Cornwall	Pennsylvania	Miners Village	Magnetite	323,592
49	Norman	Minnesota	Virginia	Hematite	314,535
50	Leonard-Burt	do	Chisholm	do	310,845
51	Albany	do	Hibbing	do	297,855
52	Penn group	Michigan	Norway and Vulcan.	do	297,550
53	Carpenter	do	Crystal Falls	do	283,507
54	Miller	Minnesota	Aurora	do	282,843
55	Lincoln	do	Virginia	do	266,149
56	Riverton group	Michigan	Iron River	do	264,642
57	Tully	do	Stambaugh	do	253,404
58	Sliver	Minnesota	Virginia	do	252,347
59	Bangor	do	Biwabik	do	248,905

Iron ore mines of the United States that produced more than 50,000 gross tons each in 1915—Continued.

Rank.	Name of mine.	State.	Nearest town.	Variety of ore.	Quantity mined.
					Gross tons.
60	Union	Minnesota	Virginia	Hematite	245,526
61	Harrison	do	Nashwauk	do	239,074
62	Pewabic	Michigan	Iron Mountain	do	232,965
63	Ottawa	Wisconsin	Montreal	do	227,237
64	Raimund, No. 1	Alabama	Bessemer	do	221,955
65	Songo	do	Songo	do	210,369
66	Hudson	Minnesota	Aurora	do	204,638
67	Woodbridge	do	Buhl	do	204,121
68	Thompson	do	Crosby	do	202,640
69	Kennedy	do	Cuyuna	do	202,082
70	Aurora	Michigan	Ironwood	do	195,546
71	Grant	Minnesota	Buhl	do	189,748
72	Cary	Wisconsin	Hurley	do	187,406
73	Laura	Minnesota	Hibbing	do	186,246
74	Elba	do	Gilbert	do	185,594
75	Aragon	Michigan	Norway	do	183,518
76	Belgrade	Minnesota	Biwabik	do	180,414
77	Richmond	Michigan	Palmer	do	177,304
78	Lake Superior	do	Ishpeming	do	176,461
79	Balkan	do	Alpha	do	175,123
80	Chicagon	do	Iron River	do	172,585
81	North Harrison	Minnesota	Nashwauk	do	169,946
82	Mace, No. 1	do	Keewatin	do	169,824
83	Zimmerman	Michigan	Gaastra	do	165,818
84	Cambria	do	Negaunee	do	163,957
85	Dale	Minnesota	Hibbing	do	162,585
86	Rolling Mill	Michigan	Negaunee	do	161,323
87	Glen	Minnesota	Chisholm	do	160,883
88	North Uno	do	Hibbing	do	158,961
89	Greeley	Alabama	Greeley	Brown ore	157,914
90	Chatham	Michigan	Stambaugh	Hematite	157,820
91	American-Boston	do	Diorite	do	154,535
92	Mississippi	Minnesota	Keewatin	do	153,148
93	Section 30	do	Ely	do	147,638
94	Mary Charlotte, Nos. 1 and 2	Michigan	Negaunee	do	146,621
95	Rowe	Minnesota	Riverton	do	143,163
96	Mount Hope	New Jersey	Mount Hope	Magnetite	138,713
97	Eureka	Michigan	Ramsay	Hematite	133,941
98	Brown Mining Co	Tennessee	Cardiff	do	133,079
99	Itasca	Minnesota	Buhl	do	126,002
100	Corsica	do	Gilbert	do	125,477
101	Steinman	Alabama	Steinman	do	125,133
102	Washington	New Jersey	Oxford	Magnetite	123,049
103	Homer	Michigan	Iron River	Hematite	121,909
104	Raimund, No. 2	Alabama	Bessemer	do	118,911
105	Pennington	Minnesota	Ironton	do	117,068
106	Sunday Lake	Michigan	Wakefield	do	115,903
107	Ernst Mine	Wisconsin	Commonwealth	do	113,543
108	Ashland	Michigan	Ironwood	do	111,888
109	Grace	Minnesota	Hibbing	do	110,296
110	Adriatic	do	Mesaba	do	106,485
111	Forbes	Michigan	Iron River	do	105,620
112	Pettit	Minnesota	Gilbert	do	103,826
113	Helmer	do	Kinney	do	101,000
114	Osana	Michigan	Iron River	do	100,922
115	Portland	do	Michigamme	do	97,476
116	Tilden	do	Bessemer	do	92,832
117	South Uno	Minnesota	Hibbing	do	92,293
118	Myers	do	Chisholm	do	91,534
119	Quinn	do	Nashwauk	do	91,007
120	Loretto	Michigan	Loretto	do	88,981
121	Attalla	Alabama	Attalla	do	88,712
122	Soudan	Minnesota	Soudan	do	85,853
123	Hiawatha	Michigan	Iron River	do	85,127
124	Sibley	Minnesota	Ely	do	84,927
125	Richards	Michigan	Crystal Falls	do	84,111
126	Friedman	Alabama	Woodstock	Brown ore	81,684
127	Wanless	Minnesota	Buhl	Hematite	80,386
128	Mayville	Wisconsin	Mayville	do	80,310
129	Shiras	Minnesota	Buhl	do	79,909
130	Armour, No. 1	do	Crosby	do	79,773
131	Savoy	do	Ely	do	79,166
132	Castile	Michigan	Wakefield	do	78,550
133	Brotherton	do	do	do	78,244
134	Ironaton	Alabama	Ironaton	Brown ore	77,870
135	Houston	do	Rickey	do	77,453
136	Weed	Minnesota	Mesaba	Hematite	75,492
137	Deacon	do	Buhl	do	75,455
138	Buckeye	Wisconsin	Commonwealth	do	75,142

Iron ore mines of the United States that produced more than 50,000 gross tons each in 1915—Continued.

Rank.	Name of mine.	State.	Nearest town.	Variety of ore.	Quantity mined.
					Gross tons.
139	Raimund, No. 3	Alabama	Bessemer	Hematite	74,563
140	Breitung Hematite, No. 2	Michigan	Negaunee	do	73,778
141	South Chandler	Minnesota	Ely	do	73,018
142	Tannehill	Alabama	Goethite	Brown ore	70,991
143	Davidson, No. 2	Michigan	Iron River	Hematite	69,349
144	Knox	Minnesota	Mesaba	do	69,323
145	Breitung Hematite, No. 1	Michigan	Negaunee	do	68,608
146	Bennett	Minnesota	Keewatin	do	66,469
147	Franklin	do	Virginia	do	66,117
148	Oriskany	Virginia	Oriskany	Brown ore	65,745
149	Cranberry	North Carolina	Cranberry	Magnetite	65,596
150	Davidson, No. 1	Michigan	Iron River	Hematite	65,423
151	Rogers	do	do	do	64,938
152	Richard	New Jersey	Wharton	Magnetite	63,667
153	Philbin	Minnesota	Hibbing	Hematite	58,383
154	Isabella	Michigan	Palmer	do	57,188
155	Ruddy	Minnesota	Biwabik	do	57,100
156	Docray	Alabama	Docray	Brown ore	56,729
157	Champion	do	Oneonta	do	55,427
158	Morton	Minnesota	Hibbing	Hematite	55,327
159	Wacoutah	do	Mountain Iron	do	54,200
160	Minorca	do	Virginia	do	53,978
161	North Anvil	Michigan	Bessemer	do	53,872
162	Duncan	Minnesota	Chisholm	do	52,401
163	Thorne	do	Buhl	do	51,409
164	Puritan	Michigan	Ironwood	do	51,242
165	Minnewas	Minnesota	Virginia	do	50,510
166	Adams	Michigan	Ishpeming	do	50,283
167	Cahoon	Wisconsin	Baraboo	do	50,000
	Total (167 mines)				50,338,202
	Unspecified (17 mines)[a]				3,233,332
	Tonnage from mines producing more than 50,000 gross tons each.				53,571,534
	Tonnage from mines producing less than 50,000 gross tons each.				1,954,956
	Grand total of United States.				55,526,490

[a] Includes the product of 17 mines producing over 50,000 gross tons each, operated by 8 companies, which do not permit the publication of individual figures.

STOCK OF IRON ORE AT MINES.

According to the reports of producers, some of which have been revised since the report for 1914 was published, the total quantity of iron ore in stock at the mines at the close of 1915 amounted to 13,748,732 gross tons, compared with 13,759,494 tons at the close of 1914. As the tonnage of ore in stock piles is necessarily partly estimated, there are variations in the mine reports from year to year which prevent an absolute balance between the quantity mined and the quantity sold and stocks on hand.

The following table gives the reported stocks of iron ore at the mines December 31, 1914 and 1915, by States:

Stock of iron ore at mines Dec. 31, 1914 and 1915, in gross tons.

State.	1914	1915	State.	1914	1915
Alabama	564,331	737,937	New York	214,626	270,193
Georgia	2,260	13,803	Ohio	3,435	3,388
Maryland	5,654	9,654	Pennsylvania	43,037	38,766
Massachusetts	2,000	2,000	Tennessee	30,144	30,488
Michigan	6,748,510	5,582,782	Virginia	74,931	84,329
Minnesota	5,359,906	6,273,496	Wisconsin	551,415	518,472
Missouri	5,140	5,140			
New Jersey	154,165	178,284		13,759,494	13,748,732

PRICES OF IRON ORE PER TON.

In the following table the price per ton of the different classes of iron ore in 1914 and 1915 is given for each of the producing States or groups of States, except where there were less than three producers of a certain variety of ore, and permission was not given to publish in a State whose total may be published. The total average prices per gross ton (the whole United States considered) in 1915 were: Hematite, $1.80; brown ore, $1.80; magnetite, $2.50; carbonate, $2.44, as compared with prices, respectively, of $1.79, $1.72, $2.39, and $2.44, in 1914. These figures represent the price at the mines and are taken directly from statements of the producers. They are probably only approximately correct. The element of inaccuracy lies in the fact that by far the greater bulk of the iron ore produced in the United States is mined by iron and steel producers for their own furnaces and in the further fact that the value placed on such ore is therefore largely a matter of accounting. Some of the reports made to the Survey evidently include merely actual mining costs; others contain, in addition, the cost of selling and insuring the ore; in others an allowance for sinking fund is included; and in still others the figures given are prices used in charging costs against the blast furnaces. At any rate, they include no freight costs.

The general average price per gross ton of all kinds of iron ore in the United States was $1.83 in 1915, compared with $1.81 in 1914, an increase of 2 cents a ton, or slightly more than 1 per cent. The prices of the Lake Superior ores at the lower Lake ports are given in subsequent tables.

Average price per gross ton of iron ore shipped from mines in the United States in 1914 and 1915.

State.	Hematite.		Brown ore.		Magnetite.		Carbonate.	
	1914	1915	1914	1915	1914	1915	1914	1915
Alabama	$1.21	$1.25	$1.49	$1.68				
California					$4.00	$4.00		
Colorado			1.99	(a)		(a)		
Georgia	1.70	1.53	1.82	1.88				
Maryland			2.43	1.83				
Michigan	2.19	2.07						
Minnesota	1.74	1.77						
Missouri	2.10	2.55	(a)	(a)				
Montana			(a)					
New Jersey					3.10	2.92		
New Mexico			(a)	1.56				
New York	2.10	(a)		(a)	3.17	3.08		
Ohio							$2.44	$2.44
Pennsylvania	(a)	(a)	2.89	2.59	(a)	.77		
Tennessee	1.23	1.30	1.69	1.67	(a)	(a)		
Virginia	1.74	1.91	2.16	2.04		(a)		
Wisconsin	1.99	1.94						
Other States [b]	1.01	.97	2.83	2.87	1.31	1.60		
Total average	1.79	1.80	1.72	1.80	2.39	2.50	2.44	2.44

[a] Less than three producers and permission to publish not given; therefore price may not be shown.
[b] 1914: Connecticut, Idaho, Kentucky, Massachusetts, Mississippi, Montana, Nevada, New Mexico, North Carolina, Utah, West Virginia, and Wyoming; 1915: Colorado, Connecticut, Idaho, Massachusetts, Nevada, North Carolina, Utah, and Wyoming.

Average price per gross ton of iron ore in the United States, 1889 and 1892 to 1915.

Year.	Hematite.	Brown ore.	Magnetite.	Carbonate.	General average.
1889					$2.30
1892					2.04
1893					1.66
1894					1.14
1895					1.14
1896					1.42
1897					1.08
1898					1.14
1899					1.42
1900					2.42
1901					1.71
1902					1.84
1903					1.89
1904					1.56
1905					1.77
1906	$2.13	$1.78	$2.05	$1.75	2.11
1907	2.63	1.81	2.03	1.74	2.55
1908	2.32	1.70	2.10	1.38	2.27
1909	2.17	1.68	2.40	1.73	2.15
1910	2.52	1.76	2.36	1.61	2.47
1911	2.12	1.72	2.29	1.83	2.11
1912	1.87	1.79	2.18	1.96	1.88
1913	2.21	1.88	2.07	2.06	2.19
1914	1.79	1.72	2.39	2.44	1.81
1915	1.80	1.80	2.50	2.44	1.83

APPARENT CONSUMPTION OF IRON ORE COMPARD WITH PRODUCTION OF PIG IRON.

The following table includes data on certain items from which an approximate estimate of the annual consumption of iron ore in the United States is deduced. The result is, of course, merely an approximation, for no data are available on certain items, such as stocks at furnaces, which should enter into the final result. The items considered in the table and in the annual estimates for all years preceding 1911 are (1) domestic iron ore mined; (2) stocks of ore at mines; (3) stocks of ore at lower Lake ports; (4) production of zinc residuum; (5) imports of ore; (6) exports of ore. Beginning with 1911 data on the shipments of ore became available, and these figures, together with zinc residuum and imports of ore, constitute the available supply, which, less the exports, gives the apparent consumption, without consideration of the stocks at mines and at Lake ports. This apparent consumption includes small quantities of ore not used in the manufacture of pig iron, such as ore consumed in the open-hearth process and in smelting gold, silver, and copper; but it does not include ore used in the manufacture of paint.

In the same table is given the production of pig iron, including ferromanganese, spiegeleisen, ferrosilicon, and other ferroalloys, for corresponding years and the ratio of pig iron produced to iron ore consumed. On later pages of the report will be found detailed statistics on the production and shipments of pig iron.

The ratio of pig iron manufactured to iron ore consumed was 53.15 per cent in 1915, as compared with 57.45 per cent in 1914. The ratio in 1914 is the highest percentage shown for the last 27 years, except that for 1893, which was apparently 61.33 per cent. The tendency in iron-ore mining to produce ore of higher grade in times of small demand than in prosperous times, when the maximum output is demanded, is clearly shown in the last column of the table. In the years 1893, 1904, 1908, 1911, and 1914 there were notable decreases in production of iron ore and in each of these years except 1908 the ratio of pig iron produced to iron ore consumed rose between 2 and 7 per cent.

The actual figures of consumption of ore as reported directly to the Survey by the manufacturers of iron are of interest in comparison with the figures in this table. Heretofore such data have not been sufficiently complete for publication, but in connection with the statistics of value of pig iron, which are collected by the Survey alone, it has been found necessary to gather related data, some of which are now sufficiently complete for publication. For instance, the quantity of domestic iron ore consumed in the manufacture of pig iron in 1915, according to reports to the Survey from blast furnaces, was 53,775,945 gross tons; the total consumption of iron ore in 1915, including imported ore and 251,593 tons of mill cinder, scale, etc., was 55,409,022 gross tons, from which was produced 29,556,944 gross tons of pig iron, exclusive of ferroalloys—a ratio of pig iron produced to ore consumed of 53.34 per cent.

Apparent consumption of iron ore compared with production of pig iron in the United States, 1889–1915, in gross tons.

Year.	Domestic iron ore produced.[a]	Stocks of ore at mines.	Stocks of ore at lower Lake ports Dec. 1.	Zinc residuum.	Imports.	Exports.	Apparent consumption.	Pig iron produced.[b]	Percentage ratio of pig iron to iron ore.
1889	14,518,041	2,256,973	2,607,106	43,648	853,573	.....	14,366,562	7,603,642	52.93
1890	16,036,043	2,000,000	3,893,487	48,560	1,246,830	.....	16,302,025	9,202,703	56.45
1891	14,591,178	2,450,279	3,508,489	38,228	912,864	.....	15,476,989	8,279,870	53.50
1892	16,296,666	2,911,740	4,149,451	31,859	806,585	.....	16,032,687	9,157,000	57.11
1893	11,587,629	3,526,161	4,070,710	37,512	526,951	.....	11,616,412	7,124,502	61.33
1894	11,879,679	3,236,198	4,834,247	26,981	167,307	.....	11,600,393	6,657,388	57.39
1895	15,957,614	2,976,494	4,415,712	43,249	524,153	.....	17,203,255	9,446,308	54.91
1896	16,005,449	3,405,302	4,954,984	44,953	682,806	.....	15,765,128	8,623,127	54.70
1897	17,518,046	3,098,287	5,923,755	33,924	489,970	.....	17,380,184	9,652,680	55.54
1898	19,433,716	2,846,457	5,136,407	48,502	187,208	.....	20,708,604	11,773,934	56.86
1899	24,683,173	2,320,278	5,530,283	65,010	674,082	40,665	25,513,903	13,620,703	53.39
1900	27,553,161	3,709,950	5,904,670	87,110	897,831	51,460	26,722,583	13,789,242	51.60
1901	28,887,479	4,239,823	5,859,663	52,311	966,950	64,703	29,357,171	15,878,354	54.09
1902	35,554,135	3,834,717	7,074,254	65,246	1,165,470	88,445	35,886,921	17,821,307	49.66
1903	35,019,308	6,297,888	6,371,085	73,264	980,440	80,611	34,232,399	18,009,252	52.61
1904	27,644,330	4,666,931	5,763,399	68,189	487,613	213,865	30,224,910	16,497,033	54.58
1905	42,526,133	3,812,281	6,438,967	90,289	845,651	208,017	43,433,138	22,992,380	52.94
1906	47,749,728	3,281,789	6,252,455	93,461	1,060,390	265,240	49,355,343	25,307,191	51.28
1907	51,720,619	3,033,110	7,385,728	93,413	1,229,168	278,608	51,879,998	25,781,361	49.69
1908	35,983,336	6,065,397	8,441,533	110,225	776,898	309,099	32,473,268	15,936,018	49.74
1909	51,294,271	6,135,271	8,965,789	141,264	1,694,957	455,934	52,080,428	25,795,471	49.53
1910	57,014,906	9,422,285	9,426,881	137,173	2,591,031	748,875	55,246,129	27,303,567	49.42
1911	41,092,447	.....	.....	109,296	1,811,732	768,386	42,245,089	23,649,547	55.98
1912	57,017,614	.....	.....	104,670	2,104,576	1,195,742	58,031,118	29,726,937	51.23
1913	59,643,098	.....	.....	102,239	2,594,770	1,042,151	61,297,956	30,966,152	50.52
1914	39,714,280	.....	.....	100,198	1,350,588	551,618	40,613,448	23,332,244	57.45
1915	55,493,100	.....	.....	159,318	1,341,281	707,641	56,286,058	29,916,213	53.15

[a] Beginning with 1910, iron ore sold for paint excluded from production and included in metallic paint. Beginning with 1911, figures represent shipments.

[b] From annual reports of the American Iron and Steel Association prior to 1912, and including ferroalloys produced in blast furnaces; beginning with 1912, according to American Iron and Steel Institute, and also including ferroalloys.

IRON-ORE INDUSTRY IN THE LAKE SUPERIOR DISTRICT.

PRODUCTION OF IRON ORE IN THE LAKE SUPERIOR DISTRICT, BY RANGES.

The Lake Superior district within the United States includes the Vermilion, Mesabi, Cuyuna, Gogebic, Marquette, and Menominee ranges in the States of Minnesota, Michigan, and Wisconsin. The Menominee range includes the Crystal Falls, Metropolitan, Iron River, and Florence areas; the Marquette range includes the Republic and Swanzy areas. The Baraboo and the Iron Ridge areas of southern Wisconsin and the Spring Valley area of northwestern Wisconsin are not properly included in the Lake Superior district. In the first group of ranges the ore mined is almost entirely Algonkian hematite, belonging to the Huronian series. The Baraboo ore is of the same nature, but the Iron Ridge ore is "Clinton" hematite and the Spring Valley ore is brown ore. Ore production was resumed in 1915 in the Baraboo area, developments having been abandoned for several years on account of unsatisfactory quality of ore and too great quantity of underground water. The Cahoon mine in Sauk County mined 50,000 tons in 1915, its first production.

The ranges in the United States which produced ore in 1915 were the Vermilion, Mesabi, Gogebic, Marquette, Menominee, and Cuyuna, besides the Baraboo and Iron Ridge areas. All the ranges in the Lake Superior district mined a larger quantity of iron ore in 1915 than in 1914, the largest increases being in the Mesabi and Cuyuna ranges—56 and 44 per cent, respectively. The output of the Cuyuna range exceeded 1,000,000 tons for the first time.

The total quantity of ore mined from the Lake Superior district, excluding the Baraboo and Iron Ridge areas, in 1915, was 46,944,254 gross tons, compared with 33,540,403 gross tons in 1914, an increase of 13,403,851 tons, or 40 per cent. An analysis of reported quantity mined in 1915, by ranges, in the Lake Superior district shows that the Mesabi range mined 30,802,409 tons, compared with 19,808,434 tons in 1914, an increase of 56 per cent; the Menominee range, 4,665,465 tons, compared with 3,671,499 tons in 1914, an increase of 27 per cent; the Gogebic range, 4,996,237 tons, compared with 4,601,240 tons in 1914, an increase of 9 per cent; the Marquette range, 3,817,892 tons, compared with 3,320,763 tons in 1914, an increase of 15 per cent; the Vermilion range, 1,541,645 tons, compared with 1,362,416 tons in 1914, an increase of 13 per cent; and the Cuyuna range, which in 1915 entered upon its fifth year as a shipper of ore, 1,120,606 tons, compared with 776,051 tons in 1914, an increase of 44 per cent. The production of manganiferous iron ore from the Cuyuna range is reported in the chapter on manganiferous iron ores in Mineral Resources, 1915.

The Mesabi range produced 66 per cent of the entire output of the Lake Superior district and 55 per cent of the entire production of the United States. The Gogebic, Menominee, and Marquette ranges are next in importance, the Gogebic producing in 1915 about 313,000 tons less than the State of Alabama, which is the next State in importance as a producer after Minnesota and Michigan. The Vermilion range is the fifth in importance of the six producing ranges of the Lake Superior district.

Iron ore mined in the Lake Superior district,[a] 1914–15, in gross tons.

Range.	1914	1915	Increase in 1915.	Percentage of increase in 1915.	Percentage of total output in Lake Superior district, 1915.
Marquette (Michigan)	3,320,763	3,817,892	497,129	15	8
Menominee (Michigan and Wisconsin)	3,671,499	4,665,465	993,966	27	10
Gogebic (Michigan and Wisconsin)	4,601,240	4,996,237	394,997	9	11
Vermilion (Minnesota)	1,362,416	1,541,645	179,229	13	3
Mesabi (Minnesota)	19,808,434	30,802,409	10,993,975	56	66
Cuyuna (Minnesota)	776,051	1,120,606	344,555	44	2
	33,540,403	46,944,254	13,403,851	40	100

[a] Includes only such Wisconsin mines as are in the true Lake Superior district.

The following table shows the total production of the Lake Superior district, by ranges. The figures prior to 1872 were collected by A. P. Swineford, editor Marquette Mining Journal;[1] those for 1872 to 1877, inclusive, are from the Michigan Mineral Statistics; those for 1878 to 1888, inclusive, were collected by W. J. Stevens;[2] and the later figures were collected by the United States Geological Survey.

Iron ore produced in the Lake Superior district, 1854–1915, in gross tons.

Year.	Marquette.	Menominee.	Gogebic.	Vermilion.	Mesabi.	Cuyuna.	Total.
1854–1869	3,112,209	.....	.....	.....	.....	.....	3,112,209
1870	859,507	.....	.....	.....	.....	.....	859,507
1871	813,984	.....	.....	.....	.....	.....	813,984
1872	948,553	.....	.....	.....	.....	.....	948,553
1873	1,195,234	.....	.....	.....	.....	.....	1,195,234
1874	899,934	.....	.....	.....	.....	.....	899,934
1875	881,166	.....	.....	.....	.....	.....	881,166
1876	993,311	.....	.....	.....	.....	.....	993,311
1877	1,014,754	10,375	.....	.....	.....	.....	1,025,129
1878	1,033,082	78,028	.....	.....	.....	.....	1,111,110
1879	1,130,019	245,672	.....	.....	.....	.....	1,375,691
1880	1,384,010	524,735	.....	.....	.....	.....	1,908,745
1881	1,579,834	726,671	.....	.....	.....	.....	2,306,505
1882	1,829,394	1,136,018	.....	.....	.....	.....	2,965,412
1883	1,305,364	1,047,863	.....	.....	.....	.....	2,353,227
1884	1,559,912	895,634	1,022	62,122	.....	.....	2,518,690
1885	1,430,862	690,435	119,590	227,075	.....	.....	2,467,962
1886	1,627,383	880,006	756,237	307,948	.....	.....	3,571,574
1887	1,851,717	1,199,343	1,285,265	394,910	.....	.....	4,731,235
1888	1,918,672	1,191,097	1,433,689	511,953	.....	.....	5,055,411
1889	2,631,026	1,876,157	2,147,923	864,508	.....	.....	7,519,614
1890	2,863,848	2,274,192	2,914,081	891,910	.....	.....	8,944,031
1891	2,778,482	1,856,124	2,041,754	945,105	.....	.....	7,621,465
1892	2,848,552	2,402,195	3,058,176	1,226,220	29,245	.....	9,564,388
1893	2,064,827	1,563,049	1,466,815	815,735	684,194	.....	6,594,620
1894	1,935,379	1,255,255	1,523,451	1,055,229	1,913,234	.....	7,682,548
1895	1,982,080	1,794,970	2,625,475	1,027,103	2,839,350	.....	10,268,978
1896	2,418,846	1,763,235	2,100,398	1,200,907	3,082,973	.....	10,566,359
1897	2,673,785	1,767,220	2,163,088	1,381,278	4,220,151	.....	12,205,522
1898	2,987,930	2,275,664	2,552,205	1,125,538	4,837,971	.....	13,779,308
1899	3,634,596	3,281,422	2,725,648	1,643,984	6,517,305	.....	17,802,955
1900	3,945,068	3,680,738	3,104,033	1,675,949	8,158,450	.....	20,564,238
1901	3,597,089	3,697,408	3,041,869	1,805,996	9,303,541	.....	21,445,903
1902	3,734,712	4,421,250	3,683,792	2,057,532	13,080,118	.....	26,977,404
1903	3,686,214	4,093,320	3,422,341	1,918,584	13,452,812	.....	26,573,271
1904	2,465,448	2,871,130	2,132,898	1,056,430	11,672,405	.....	20,198,311
1905	3,772,645	4,472,630	3,344,551	1,578,626	20,156,566	.....	33,325,018
1906	4,070,914	4,962,357	3,484,023	1,794,186	23,564,891	.....	37,876,371
1907	4,167,810	4,779,592	3,609,519	1,724,217	27,245,441	.....	41,526,579
1908	3,309,917	2,904,011	3,241,931	927,206	17,725,014	.....	28,108,079
1909	4,291,967	4,789,362	3,807,157	1,097,444	27,877,705	.....	41,863,635
1910	4,631,427	4,983,729	4,746,818	1,390,360	30,576,409	.....	46,328,743
1911	3,743,145	4,062,778	3,099,197	1,336,938	23,126,943	181,224	35,550,225
1912	3,545,012	4,465,466	3,926,632	1,457,273	32,604,756	369,739	46,368,878
1913	3,977,808	4,997,246	4,743,515	1,536,115	36,378,671	744,007	52,377,362
1914	3,320,763	3,671,499	4,601,240	1,362,416	19,808,434	776,051	33,540,403
1915	3,817,892	4,665,465	4,996,237	1,541,645	30,802,409	1,120,606	46,944,254
	116,266,083	98,253,341	87,900,570	37,942,442	369,658,988	3,191,627	713,213,051

[1] U. S. Geol. Survey Mineral Resources, 1882, p. 116, 1883.

[2] Idem, 1891, pp. 39–41, 1893.

SHIPMENTS AND RECEIPTS OF LAKE SUPERIOR IRON ORE.

According to the Iron Trade Review 47,272,751 gross tons of iron ore were shipped in 1915 from the Lake Superior district, including the Iron Ridge but not the Baraboo area in Wisconsin, compared with 32,729,726 tons in 1914. Of the total in 1915, there were 953,947 tons shipped by rail, the remainder being by boat; 707,829 tons were shipped by rail in 1914. The shipments from the Lake Superior iron-ore ranges and the Baraboo and Iron Ridge areas as reported to the Survey in 1915 amounted to 47,334,942 gross tons. This quantity is 0.1 per cent more than that published by the Iron Trade Review.

The following tables give the details of shipments and receipts of Lake Superior iron ore for the last five years:

Iron ore shipped from the Lake Superior district, 1911–1915, by ports, in gross tons.[a]

Shipping port.	1911	1912	1913	1914	1915
Escanaba, Mich	4,278,445	5,234,655	5,399,444	3,664,451	5,649,289
Marquette, Mich	2,200,380	3,296,761	3,137,617	1,755,726	3,099,589
Ashland, Wis	2,429,290	4,797,101	4,338,230	3,363,419	5,146,772
Two Harbors, Minn	6,367,537	9,370,969	10,075,718	5,610,262	8,642,942
Superior, Wis	9,920,490	14,240,714	13,788,343	11,309,748	8,342,793
Duluth, Minn	6,934,269	10,495,577	12,331,126	6,318,291	15,437,419
Total by lake	32,130,411	47,435,777	49,070,478	32,021,897	46,318,804
Total by rail	662,719	785,769	876,638	707,829	953,947
Total	32,793,130	48,221,546	49,947,116	32,729,726	47,272,751

[a] Iron Trade Review.

Iron ore shipped from the Lake Superior district, 1911–1915, by months, in gross tons.[a]

Month.	1911	1912	1913	1914	1915
April	331,645	204,042	866,387	269,686	503,832
May	3,684,819	5,919,074	7,284,212	3,852,063	5,012,359
June	4,819,996	7,567,555	7,974,444	5,502,367	6,005,091
July	5,221,373	7,600,233	8,204,416	5,784,514	7,204,020
August	5,548,311	7,760,248	7,684,285	5,869,477	8,081,117
September	5,231,069	7,287,230	7,259,662	5,431,307	7,863,146
October	4,769,965	7,010,219	6,526,103	4,242,392	7,146,873
November	2,523,253	4,072,674	3,270,958	1,068,681	4,445,129
December	.....	14,579	18,545	1,411	57,236
Total by lake [b]	32,130,411	47,435,777	49,070,478	32,021,897	46,318,804
Total by rail	662,719	785,769	876,638	707,829	953,947
Total	32,793,130	48,221,546	49,947,116	32,729,726	47,272,751

[a] Iron Trade Review.
[b] Totals by seasons will be found to vary slightly from the sums of the monthly movements, due to corrections.

Iron ore received at Lake Erie ports, 1911–1915, in gross tons.[a]

Port.	1911	1912	1913	1914	1915
Toledo	493,345	1,411,278	1,084,215	773,711	1,158,374
Huron	223,947	540,586	687,485	617,363	695,865
Lorain	2,937,605	3,771,350	3,709,213	1,677,988	3,517,258
Cleveland	4,584,211	7,914,836	8,812,583	5,519,698	7,504,697
Fairport	666,365	1,810,381	2,037,126	1,558,134	2,001,103
Ashtabula	6,359,131	8,158,080	8,336,126	5,318,788	7,813,101
Conneaut	6,931,278	7,839,831	7,849,303	6,263,480	8,573,509
Erie	289,400	547,067	713,904	260,991	707,875
Buffalo	2,802,976	5,060,642	5,506,691	2,913,273	5,339,724
Detroit	243,292	418,057	363,001	332,564	459,877
Port Colborne, Ontario, Canada	.....	.....	.....	166,665	196,077
	25,531,550	37,472,108	39,099,647	25,402,655	37,967,460

[a] Iron Trade Review.

The difference between the shipments of Lake Superior ore and the receipts at Lake Erie ports is accounted for in large part by the quantity of ore delivered at Lake Michigan ports, South Chicago, Ill., Gary and Indiana Harbor, Ind., and Milwaukee, Wis., the receipts at which ports and at smaller places being shown in the table following. It is understood that there is also a loss, probably less than 1 per cent, in handling ore between mines and lower Lake ports.

Iron ore received at Lake Michigan ports, 1911–1915, in gross tons.[a]

Port.	1911	1912	1913	1914	1915
Elk Rapids, Mich	26,814	47,947	.....	28,437	.....
East Jordan, Mich	36,232	42,878	28,444	38,158	37,658
Milwaukee, Wis	109,255	138,065	234,591	93,121	187,286
Gary, Ind	1,302,745	2,088,327	2,365,551	1,631,564	2,421,924
Indiana Harbor, Ind	365,312	514,748	455,252	661,054	689,226
South Chicago, Ill	3,685,100	5,480,105	5,572,866	3,606,587	4,195,976
Boyne City, Mich	33,000	45,000	45,028	50,098	40,401
	5,558,458	8,357,070	8,701,732	6,109,019	7,572,471

[a] Iron Trade Review.

The following table shows the total quantity of iron ore shipped from the Lake Superior district since 1854, the date of the opening of the Marquette range, the oldest of the Lake Superior ranges. This table gives the shipments as published by the Iron Trade Review and is inserted for comparison with the table giving the total production of the Lake Superior district, without regard to shipments:

Iron ore shipped from the Lake Superior district, 1854–1915, in gross tons.[a]

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1854	3,000	1876	992,764	1897	12,469,638
1855	1,449	1877	1,015,087	1898	14,024,673
1856	36,343	1878	1,111,110	1899	18,251,804
1857	25,646	1879	1,375,691	1900	19,059,393
1858	15,876	1880	1,908,745	1901	20,589,237
1859	68,832	1881	2,306,505	1902	27,571,121
1860	114,401	1882	2,965,412	1903	24,289,878
1861	49,909	1883	2,353,288	1904	21,822,839
1862	124,169	1884	2,518,692	1905	34,384,116
1863	203,055	1885	2,466,372	1906	38,565,762
1864	243,127	1886	3,568,022	1907	42,266,668
1865	236,208	1887	4,730,577	1908	26,014,987
1866	278,796	1888	5,063,693	1909	42,586,869
1867	473,567	1889	7,292,754	1910	43,442,397
1868	491,449	1890	9,012,379	1911	32,793,130
1869	617,444	1891	7,062,233	1912	48,221,516
1870	830,940	1892	9,069,556	1913	49,947,116
1871	779,607	1893	6,060,492	1914	32,729,726
1872	900,901	1894	7,748,932	1915	47,272,751
1873	1,162,458	1895	10,429,037		
1874	919,557	1896	9,934,828		703,757,811
1875	891,257				

[a] Iron Trade Review.

STOCKS OF IRON ORE AT LAKE ERIE PORTS.

The following tables contain data as to the stocks of iron ore at the Lake Erie ports at the close of navigation and at the opening of navigation for the last five years:

Stocks of iron ore at lower Lake ports, Dec. 1, 1911–1915, in gross tons.[a]

Port.	At close of navigation, Dec. 1—				
	1911	1912	1913	1914	1915
Toledo, Ohio	661,382	552,016	349,047	580,600	311,799
Sandusky, Ohio	2,471	2,472	2,472	2,471	1,871
Huron, Ohio	344,371	385,810	441,541	483,769	558,692
Lorain, Ohio	314,321	320,713	694,704	548,097	824,988
Cleveland, Ohio	1,589,491	1,888,560	1,930,720	1,757,543	1,795,962
Fairport, Ohio	636,566	565,920	478,014	406,124	413,994
Ashtabula, Ohio	3,295,862	3,350,553	3,202,807	2,749,315	2,870,204
Conneaut, Ohio	1,237,573	1,429,533	1,248,032	1,160,639	1,216,686
Erie, Pa	636,274	661,330	594,613	484,467	589,355
Buffalo, N. Y	413,353	340,261	319,726	234,880	326,800
	9,131,664	9,497,168	9,261,676	8,407,905	8,910,351

[a] Iron Trade Review.

Stocks of iron ore at lower Lake ports, May 1, 1912–1916, in gross tons.[a]

Port.	At opening of navigation, May 1—				
	1912	1913	1914	1915	1916
Toledo, Ohio	356,102	394,984	215,534	255,343	164,637
Sandusky, Ohio	2,471	2,485	2,741	2,471	.....
Huron, Ohio	257,496	293,006	308,478	462,917	286,054
Lorain, Ohio	287,294	399,705	245,057	377,550	173,771
Cleveland, Ohio	1,363,696	1,428,306	1,487,292	1,592,783	772,721
Fairport, Ohio	381,705	357,995	245,038	283,591	198,636
Ashtabula, Ohio	2,108,749	2,105,817	2,187,622	1,963,233	1,176,142
Conneaut, Ohio	229,462	135,100	495,153	564,077	41,080
Erie, Pa	585,150	449,455	461,750	412,186	342,866
Buffalo, N. Y	309,120	139,624	271,492	178,152	187,498
	5,881,245	5,706,477	5,920,157	6,092,303	3,343,405

[a] Marine Review.

PRICES OF LAKE SUPERIOR IRON ORE.

In the following table are given the prices of Lake Superior iron ore at the lower Lake ports from 1890 to 1916, according to the Iron Trade Review.

Beginning with the season of 1907 the base for the old range and Mesabi Bessemer ore has been a metallic iron content of 55 per cent natural and that of the old range and Mesabi non-Bessemer ore has been a metallic iron content of 51.5 per cent natural. For the years preceding 1907 the guarantee of Bessemer ores was 55.70 per cent iron, natural, and for the non-Bessemer ores it was 52.80 per cent, except Mesabi non-Bessemer for 1905 and 1906, when the natural iron content was 53 per cent.

The value per unit of iron for 1916 is as follows: Old range Bessemer, 8.09 cents; Mesabi Bessemer, 7.64 cents; old range non-Bessemer, 7.18 cents; Mesabi non-Bessemer, 6.89 cents, compared with 6.82 cents, 6.27 cents, 5.83 cents, and 5.44 cents, respectively, in 1915.

Selling price of iron ore per unit of iron at lower Lake ports at date of buying movement, 1890–1916.[a]

Season.	Date of buying movement.	Season iron-ore prices.			
		Old range Bessemer.	Mesabi Bessemer.	Old range non-Bessemer.	Mesabi non-Bessemer.
1890	Dec. 15, 1889	$5.50	No sale.	$5.25	No sale.
1891	June 1, 1891	4.50	No sale.	4.25	No sale.
1892	Jan. 31, 1892	4.50	No sale.	3.65	No sale.
1893	Mar. 15, 1893	3.85	$3.00	3.20	No sale.
1894	Mar. 1, 1894	2.75	2.35	2.50	No sale.
1895	Apr. 1, 1895	2.90	2.15	2.25	$1.90
1896	May 1, 1896	4.00	3.50	2.70	2.25
1897	May 20, 1897	2.60	2.25	2.15	1.90
1898	Mar. 20, 1898	2.75	2.25	1.83	1.75
1899	Feb. 1, 1899	3.00	2.40	2.15	2.00
1900	Dec. 15, 1899	5.50	4.50	4.25	4.00
1901	Apr. 15, 1901	4.25	3.25	3.00	2.75
1902	Feb. 1, 1902	4.25	3.25	3.25	2.75
1903	Mar. 20, 1903	4.50	4.00	3.60	3.20
1904	Apr. 15, 1904	3.25	4.00	2.75	2.50
1905	Feb. 1, 1905	3.75	3.50	3.20	3.00
1906	Dec. 5, 1905	4.25	4.00	3.70	3.50
1907	Nov. 5, 1906	5.00	4.75	4.20	4.00
1908	June 15, 1908	4.50	4.25	3.70	3.50
1909	May 10, 1909	4.50	4.25	3.70	3.50
1910	Dec. 24, 1909	5.00	4.75	4.20	4.00
1911	Apr. 21, 1911	4.50	4.25	3.70	3.50
1912	Mar. 20, 1912	3.75	3.50	3.00	2.85
1913	Nov. 19, 1912	4.40	4.15	3.60	3.40
1914	May 1, 1914	3.75	3.50	3.00	2.85
1915	Apr. 19, 1915	3.75	3.45	3.00	2.80
1916	Dec. 7, 1915	4.45	4.20	3.70	3.55

[a] Iron Trade Review.

MINING DEVELOPMENTS.

Extended and authoritative reviews of developments in the iron ranges have appeared recently in the Iron Trade Review,[1] from which many of the following notes are derived:

EXPLORATION AND PROSPECTING.

Comparatively little exploratory or drilling work was done in Minnesota in 1915, but reports are current that an ore body has been located in territory between the known portions of the Mesabi and the Cuyuna ranges. It this be true it may prove to be a forerunner of very important discoveries. Merchantable ore is also reported to have been developed west of Pokegama Lake, in the vicinity of Grand Rapids on the western Mesabi.

During 1915 the number of drills operating in the Cuyuna range decreased considerably, but stripping, sinking shafts, and other operations characteristic of later stages of mining developments made good progress, insuring for 1916 an increased output.

The Wisconsin State Geological Survey has been advocating drilling for iron ore in Douglas, Sawyer, Washburn, and Bayfield counties of that State, basing its recommendations on the fact that magnetic action during surveys was observed to be almost the same as in proved ore fields of Michigan. Glacial drift covers the surface so thickly that there are not many bedrock exposures in this part of Wisconsin.

[1] Estep, H. C., Iron range developments in 1915: Iron Trade Rev., Jan. 6, 1916, pp. 81–92.
Zapffe, Carl, Development of the Cuyuna range: Iron Trade Rev., Dec. 9, 1915, pp. 1131–1133, 1154b.

IRON-ORE RESERVES IN MINNESOTA.

Estimates of ore reserves in Minnesota show a decrease of 3,254,423 tons from May 1, 1914, to May 1, 1915. Both the Mesabi and the Vermilion ranges show decrease, but on account of new discoveries the Cuyuna range reserves show increase, as appears in the following table:

Iron-ore reserves in Minnesota, May 1, 1914 and 1915.[a]

Range.	Gross tons.	
	1914	1915
Mesabi	1,386,093,626	1,382,644,910
Vermilion	11,373,349	10,209,902
Cuyuna	70,857,865	72,215,605
	1,468,324,840	1,465,070,417

[a] Iron Trade Rev., Jan. 6, 1916, p. 85.

STRIPPING.

The development of deeper and deeper open-pit mines in place of underground mines has both necessitated and depended on the development of larger scale machines and new methods for stripping the overburden, which generally consists of glacial clay, gravel, and sand. One of the largest steam shovels ever constructed was utilized at the Mace-Annex mine, at Nashwauk, in 1915. This shovel is of the revolving type, the gross weight is 400 tons, and it has 60-foot boom, 85-foot mast, and 6-yard dipper. It is said to take out a cut 150 to 200 feet wide and 40 to 60 feet high and to be able to load one hundred and twenty-five 20-yard cars in a 10-hour shift. It is reported to effect considerable saving in labor, as it requires only 2 pitmen, whereas a gang of 4 to 6 men is employed in connection with an ordinary shovel.

Hydraulic stripping is favored on the Cuyuna range, where much of the overburden is sandy. The material is sluiced down into sumps by hydraulic giants and the sludge is pumped out of the sumps by motor-driven sand pumps. The Rowe mine, at Riverton, affords an example of hydraulic stripping. At the Hillcrest mine it is planned to remove 1,000,000 cubic yards of overburden by hydraulic outfit, about half that quantity having been disposed of at the close of 1915. Here the sluicing streams are fed by a 4,000-gallon pump under a pressure head of 170 feet. The sludge, which contains about 16 per cent solids, is raised by a 4,000-gallon single-stage motor-driven sand pump mounted on a flat car. This pump operates against a static head of 52 feet and a friction head of about 100 feet. Bowlders the size of a man's head are said to be moved successfully. The complete hydraulic stripping outfit is said to cost $12,000; a complete steam-shovel outfit might cost as much as $50,000. Uusually favorable costs are reported for this hydraulic operation—about 10 cents a cubic yard, which is said to be about half the cost of steam-shovel stripping.

ORE CONCENTRATION.

Ore-washing plants have been in operation in Minnesota for several seasons—one of them for six or seven years. In 1915 there were 5 active plants in the western part of the Mesabi range, 1 at Coleraine and 4 at Nashwauk, and 3 on the Cuyuna range. The results obtained from the western Mesabi plants are reported to be more favorable than were anticipated, the ore being susceptible of more rapid handling, being easier of concentration, and yielding richer concentrates than were at first considered probable. The washer at the La Rue mine at Nashwauk is an experimental one, but capable of handling a substantial quantity of ore. During the season of 1915 about 25,000 tons of ore are reported to have been washed. The plant is designed to use a minimum quantity of water and is said to require only about 200 gallons per ton of ore. The following analyses of ore and concentrates are given by the Iron Trade Review:[1]

Analyses of crude and concentrated iron ore, La Rue washer, Nashwauk, Minn.

	Crude ore.	Concentrate.
Iron.....per cent..	51.50	59.14
Phosphorus.....do....	.026	.037
Manganese.....do....	.42	.50
Silica.....do....	22.10	9.44
Water.....do....	12.00	8.50
Extraction.....by weight iron units..	88.60	.....
Yield.....do....	80.96	.....

At the Rowe mine, on the Cuyuna range, where some of the ore is interbanded with cherty silica, a washer employing a system of jigs for thorough sizing of the ore and waste has been put in operation.

At the experiment station of the Minnesota University School of Mines some promising work has been done on concentration of lean magnetite ore. Experimental magnetic washing apparatus has been designed and built, and it is understood that the principles under investigation here have been embodied in a large commercial experimental plant, capable of treating about 25,000 tons of lean ore during the season, which was completed at Duluth about the middle of 1916. The process of magnetic washing requires very fine grinding of the ore, a feature that involves considerable expense. The reserves of lean magnetic ore in the eastern Mesabi range are so vast, however, that a great deal of careful work is warranted in the effort to make the ore commercially available.

At some mines the separation of ore from rock occurring in it in streaks and patches is becoming an important problem. An alternative would be to stock-pile the ore and rock mixture for future handling, but most fee owners prefer to have the ore separated at once. A rough separating apparatus employing a grizzly and a picking table, or apron, has been devised, but thus far it has not been possible to substitute a more economical method for the expensive picking by hand.

[1] Estep, H. C., op. cit., p. 88

LABOR CONDITIONS.

According to recent statistics of nationality taken by the Oliver Iron Mining Co., about 90 per cent of its employees on the Mesabi range are foreigners, of whom about 56 per cent are Austrians, 14 per cent are Finns, and 11.5 per cent are Italians. At the beginning of the war in Europe it was feared that there would be a large exodus of unnaturalized foreign laborers to join their native colors, but time has shown that most of these laborers prefer to remain in the United States. There may be a shortage of labor in 1916, because of the extraordinary demand for iron ore, but a serious danger to large production of ore is the possibility of strikes by the miners. One factor that will go far toward promoting safety and efficiency in iron mining in this part of Minnesota is the prohibition of the sale of liquor. No liquor is now permitted to be sold in any of the iron-ore region of Minnesota except the Vermilion range and the Mesabi range east of Buhl. The United States Government is credited with having greatly aided the prohibition movement through the enforcement of one of the provisions of a treaty made with the Chippewa Indians living in northern Minnesota which covers the disposition of their lands and the relations between the Government and the tribe and which provides for complete prohibition; no liquor is allowed within the specified territory, even on the persons of individuals.

The Federal Government has, through the Bureau of Mines, done much valuable educational work among the iron miners by teaching selected groups of them the principles of first aid and other features of rescue work and by introducing to them by means of moving pictures many of the problems of safety in mining.

TRANSPORTATION.

Owing to the cancellation of the Hill ore lease by the United States Steel Corporation the Duluth, Missabe & Northern Railway once more gained first place as an ore carrier between the Mesabi range and the docks at the head of Lake Superior, supplanting the Great Northern Railway, which has held first place for several years. The Missabe road's shipments in 1915 are reported to be 15,437,419 gross tons, or about 52 per cent of all Mesabi range shipments and about 33 per cent of all Lake shipments for 1915. The Duluth & Iron Range Railroad carried 8,642,942 gross tons and the Great Northern 7,209,150 tons.

The new iron ore dock, No. 5, of the Duluth, Missabe & Northern Railway, at Duluth, said to be the largest loading dock in the world, began operations April 20, 1915. It required more than two years for its construction. This dock is 2,304 feet long and has 384 pockets with a storage capacity of 134,400 tons.[1] Contracts are reported to have been let for a large new ore dock at Two Harbors, Minn. This dock will be 1,431 feet long and will contain two hundred and twenty-eight 300-ton pockets—a little more than half the capacity of Dock No. 5 at Duluth.

[1] Iron Trade Rev., Dec. 9, 1915, p. 1135.

BENEFICIATION OF LAKE SUPERIOR IRON ORES.

By Edmund Newton and Harlan H. Bradt.[1]

HISTORICAL STATEMENT.

Since the earliest mining in the Lake Superior region there has been an effort to improve the quality and the texture of the iron ores. This is evident in selective mining, where the material blasted or picked down is, so far as practicable, only of the character desired. After breaking down the material, pieces of waste are picked by hand from the ore, thrown into old openings or placed to one side, and later carried to the surface or to another part of the mine where they can be disposed of. Generally, at the shaft the ore is dumped through a grizzly into a pocket or into a skip, the large pieces of ore remaining on the bars. These are sledged, both to facilitate handling in further transportation, to eliminate waste rock, and to make a more desirable ore for the furnaceman. In some mines underground sizing is purposely employed to separate the large pieces, which are known to be mainly waste.

When the ore reaches the surface it is frequently subjected to another screening operation before dumping into surface tramcars or pockets. Lean pieces are rejected by the landers. Furthermore, if the ore is stock piled, a man is often kept sorting out waste rock from the coarser material at the foot of the pile and sledging and separating pieces of attached ore and rock.

Crushing of iron ore has been adopted at numerous mines, and the advantages of crushed ore were early recognized.

Devices to facilitate hand picking have been used at two mines at least in Michigan, and one is presently in use at the Ohio mine, near Michigamme, on the Marquette range. At the Helen mine, Michipicoten range, Ontario, Canada, the crude ore is crushed and screened and then passed over a picking belt to eliminate as far as possible pieces of pyrite.

It is evident that beneficiation of iron ores has, in a more or less crude way, been effective in the Lake region since the commencement of mining. It is of interest to call attention to this fact, inasmuch as it has been considered that the use of mechanical means of beneficiation is a radical step, whereas the Lake region, as a matter of fact, has been approaching such treatment of ore in a logical manner. The miner has unconsciously been practicing beneficiation of iron ore since the opening of the region. The step from crude means of sorting and breaking ore to mechanical processes adapted to the same purpose may be likened to the step from shoveling by hand to steam shoveling stock piles and mechanically loading ore underground.

The advance to methods of beneficiation on a large scale has been due to the desire to make available deposits of material below commercial grade—to treat parts of high-grade deposits which can be easily and cheaply mined but which if not recovered in the first mining operation will thereafter be inaccessible—in general, to practice efficiency and conservation. To a small extent some of the more farsighted companies have been prompted to investigate methods of beneficiation because of the approaching exhaustion of the supply of high-grade ore in the region.

[1] Mines Efficiency Co., Duluth, Minn.

The possible improvement in grade of iron ores by mechanical means has been under serious consideration in the Lake Superior region since 1888. At that time John C. Fowle installed a small magnetic separation plant on the Marquette range at the Michigamme mine, Michigamme, Mich. The material treated was lean amphibole-magnetite rock. In the Transactions of the American Institute of Mining Engineers (vol. 19, p. 62), Mr. Fowle states that in 1889 there were shipped from this property 11,000 tons of concentrates carrying between 60 and 65 per cent iron. In 1890, there were shipped 15,000 tons. The plant had a daily capacity of 180 to 200 tons. The material was crushed, treated on dry magnetic separators, and loaded on cars at a cost of 18 cents per ton of concentrates. The recovery of concentrates varied from 50 to 70 per cent. The tailings carried from 21 to 24 per cent iron. The reasons for discontinuing this operation can not be ascertained.

About 1890 a concentrating plant was installed at the Groveland mine, Menominee range, 4 miles east of Randville, Mich. It was intended to treat a uniformly hard hematite ore mixed with diorite, containing 48 to 50 per cent iron. Rather fine crushing was necessary, and it was hoped to produce a concentrate carrying approximately 65 per cent iron, dry, and lower in phosphorus than the crude ore. Jigging and treatment on slime tables was tried, but after a short period of operation, work was suspended and never resumed. (This information was obtained through private communication.)

In 1891, N. H. and H. V. Winchell, in predicting the future use of the lean magnetite ores of the Gunflint and eastern Mesabi range, in Bulletin 6 of the Minnesota Geological and Natural History Survey, mentioned that material of similar character had been concentrated by jigging at the Chateaugay mines, Lyon Mountain, N. Y., and also at the Croton mines in Putnam County, N. Y., and in Pennsylvania and New Jersey. They suggested a similar treatment for this Minnesota material. Shortly afterward, the present productive or high-grade portions of the Mesabi range were opened, with the result that naturally rich ore was available in quantity and with mining conditions hitherto undreamed of. Concentration of the lean magnetites was consequently forgotten for many years.

In 1899 L. M. Hardenburgh installed a small jigging plant for the Pewabic Mining Co. at its Pewabic mine, near Iron Mountain, Mich. Mr. Hardenburgh describes this plant in the Transactions of the Lake Superior Mining Institute, volume 6, page 23. The material treated consisted of fragmental iron ore contained in a sandstone. The fragments of ore were rounded and waterworn and their distribution throughout the sandstone was fairly uniform. They varied from the size of a pea to masses several hundred pounds in weight.

The material as hoisted from underground was passed over a grizzly, with bars spaced 1½ inches apart. The oversize was hand picked, the clean ore and clean rock being separately removed. The remainder was crushed in a jaw crusher and rolls. After screening, it was treated on 18 Hartz jigs. The capacity of the mill was approximately 300 tons a day. It is understood that this operation was discontinued on account of exhaustion of the ore body.

The next consideration of the possibilities of concentrating Lake Superior iron ores appears to have been in 1901, when Walter Bar-

rows, jr., Charles A. Purdon, and associates were exploring the sandy ores of the Arcturus property on the western Mesabi range, Minnesota. To determine whether this material was amenable to concentration, they sent a carload to Cedartown, Ga., for treatment on log washers. The results were satisfactory, and they subsequently installed a small screening and jigging plant on the property. A screening plant was also installed by Chester A. Congdon and associates at the Holman mine near by. These plants demonstrated that a separation could be made between the ore and the sand.

In 1906 and 1907 a roaster was installed at the blast-furnace plant of the Atikokan Iron Co. (Ltd.), Port Arthur, Ontario, to treat the high-sulphur magnetites from the Atikokan range.[1] Blast-furnace gas was used to give the required heat. Sulphur was reduced from about 2.50 per cent in the crude ore to about 0.25 per cent in the roasted product. The roaster used was oblong in shape, supported on steel legs, and divided into 16 sections, each containing separate combustion, roasting, and chimney chambers. The products of combustion passed through the ore to the chimney chambers, where they were drawn by exhaust fans into a chimney. The ore, which was fed from the roaster bins, remained in the roaster for 24 hours, each chamber holding 25 tons.

It is reported that a concentrating plant was built between 1900 and 1908 at the Jackson mine, near Negaunee, Mich., but this could not be substantiated.

The Oliver Iron Mining Co. began experimental work on the possible treatment of the sandy ore of the western Mesabi range in 1907. This company erected an experimental plant on the shores of Trout Lake. Extensive experiments were carried on and a satisfactory method of treating this material was evolved.

A series of metallurgic experiments were begun in 1908 at Iron Mountain, Mich., by John T. Jones. A cylindrical rotary kiln fired by a producer-gas flame was used to heat lean siliceous iron ore mixed with coal. It was found impracticable to obtain certain desired results, but it was possible to deoxidize, or metallize, the iron oxide below the fusing temperature of the gangue, and later to crush and separate the material magnetically. The producer-gas flame was soon abandoned and a powdered-coal flame used instead. Before introduction the ore was crushed. The Iron Mountain plant was operated intermittently from 1908 to 1911, when it was abandoned.

In 1908 a magnetic cobbing plant was erected at Moose Mountain, Ontario, where a metamorphic, relatively thick banded magnetite ore was coarsely crushed and separated on magnetic separators. From a crude material containing 35 per cent iron a concentrate was obtained carrying about 54 per cent iron.

As a result of the experiments made by the Oliver Iron Mining Co., at Trout Lake in 1907 and following years, a large washing plant was erected at Coleraine, Minn., which began operations in 1910. It has been in successful operation since that time and has been the model for several later plants. This plant consists of five units, each having a crude-ore capacity of approximately 7,000 tons in 20 hours. Each unit consists of the following concentrating apparatus: One 500-ton crude-ore bin; 1 grizzly, 12-inch centers; 1 trommel,

[1] Ontario Bur. Mines Seventeenth Rept., p. 319, 1908.

20 feet long, 1¼-inch round hole; 1 picking belt, 35 inches wide; 2 log washers, 25 feet long, steel; 2 auxiliary log washers, or turbos, 18 feet long, steel; 3 settling tanks; 20 Overstrom tables.

At Moose Mountain, Ontario, a crushing and fine-grinding plant, followed by Gröndal wet magnetic separators, was installed in 1911 and 1912. This plant was designed to treat the magnetic iron formation in which the gangue and the ore were intimately intermixed. The fine concentrate produced contained about 63 per cent iron and required agglomeration, and for this purpose Gröndal briquetting kilns were used. Several changes have been made in the plants and in 1915 further experiments were being conducted.

In 1910 a series of tests were made at the Newport mine, Gogebic range, Mich., for which a Bradford breaker was installed, to disintegrate and screen low-grade cherty ore. The oversize of a 1¼-inch screen was hand picked on a moving belt.

The first installation for agglomerating iron ore in the Lake region was made in 1911 by the Northwestern Iron Co., at Mayville, Wis. Gröndal briquetting kilns were used to briquet fine Clinton hematite from the mine and flue dust from the blast furnace near by.

The first drying plant to be installed in the Lake region was a rotary drier at the Hollister mine, Crystal Falls, Mich., which was completed in 1911 by the M. A. Hanna Co.

During 1912 a washing plant erected by the International Harvester Co. at the Hawkins mine, near Nashwauk, Minn., began operations. This plant consisted of one unit similar to the Coleraine plant, except that no tables were installed.

In 1912, a small plant was erected by A. B. Coates at the Madrid mine, Virginia, Minn. The ore was mined underground. It was desired to remove a certain amount of sandy silica, which was mixed with the ore. A trommel and log washer were first installed. The log washer abraded the ore particles, producing an excessive amount of fine hematite, which was lost in the tailings. Consequently a separator invented by Mr. Wetherbee was installed.

In 1912 a drying plant for reducing excessive moisture in certain materials was installed by the M. A. Hanna Co. at their Brunt mine.

Further metallizing experiments were made by John T. Jones at Republic, Mich., in 1912, at a plant built during that year. Bruckner rotary kilns were used in which to carry on the deoxidation, and, after metallizing, the material was crushed and separated on Ball-Norton and Dings magnetic separators. As the metallic product was too fine for convenient shipping and further treatment, it was attempted to briquet it under pressure. Operations were suspended in 1912.

During the season of 1912, a mines experiment station was organized at the School of Mines, University of Minnesota, Minneapolis, Minn. The purpose of this station was to aid the mining industry of the State. On account of the activity in the concentration of iron ores, this investigation was taken up in detail. A testing plant was equipped with suitable machinery for the testing of various types of low-grade Minnesota iron ore. General investigations have since been made on the sandy Mesabi ore, on Cuyuna ores, on the lean magnetites of the eastern Mesabi range, and on the titaniferous magnetite of Cook and Lake counties. A large number of tonnage tests

have been made for many of the mining companies. Bulletins are published from time to time as data become available. (See Bibliography, pp. 337–341.)

During 1910, 1911, and 1912 calcining experiments were made on the carbonate ore from the Magpie mine, Michipicoten range, Ontario, by the Algoma Steel Co. In 1911 and 1912 a calcining plant consisting of a 120-foot rotary calcining kiln, followed by two 60-foot rotary roasting kilns, was installed. Previous to the heat treatment the material was crushed to 1½ inches. In 1913 the two small kilns were dispensed with, the whole operation being performed in the 120-foot kiln. Five units are now installed, and the capacity is about 20,000 tons a month.

In 1913 two concentrating plants were installed by the M. A. Hanna Co., one at the La Rue mine at Nashwauk, on the Mesabi range, Minn., and the other at the American Boston mine, Diorite, Mich. Both of these plants included novel features of treatment. The La Rue ore was of the "sandy type," somewhat similar to the Hawkins ore. Instead of using the customary log washers, however, a Wetherbee separator and a Woodbury slime classifier jig were installed, in parallel, for testing. Wilfley tables were used to recover the fine mineral. The Wetherbee separator operates by a combination of centrifugal force and an uprising current of water. The fine sand rises with the water current and overflows, while the lumps, which are good ore, drop to the bottom and are withdrawn as concentrates. At the American Boston mine the ore was of a hard banded character, containing coarse particles of cherty silica as gangue. An extensive plant was erected with Richards pulsator jigs as the main concentrating units.

In 1914 another drying plant was erected by the Shenango Furnace Co. at their Whiteside mine on the Mesabi range.

A new metallizing plant was built by John T. Jones in 1914 at Marquette, Mich. A furnace of the shaft type was used into which the ore was introduced from a rotary preheater, through which the waste gases from the furnace passed into a stack. At the close of 1915 experiments were still being conducted at Marquette, various changes having been made in the apparatus.

In 1915 considerable activity in beneficiation was shown. Two washing plants, consisting of single units of relatively standard type, including log washers and tables, were installed on the Mesabi range, one by Butler Bros., of St. Paul, at the Quinn-Harrison mines, and the other by the Cleveland Cliffs Iron Co., at the Crosby mine. Both of these plants are near Nashwauk, Minn.

During 1915 the concentration of Cuyuna range ores was also begun. The Inland Steel Co. installed a small washing plant consisting mainly of screens and log washers at the Thompson mine, Crosby, Minn. The Pittsburgh Steel Ore Co. also installed a washing plant of considerable size at the Rowe mine, Riverton, Minn. At the time this plant was built, log washers and tables were installed to remove the sandy silica, but it was proposed later to install jigs for the purpose of removing the coarser chert. A small experimental washing and hand-picking plant was installed at the Cuyuna-Sultana mine to treat manganiferous iron ore.

In 1915 experimental work was begun on an extensive scale on the lean magnetites of the eastern Mesabi range. A large amount of this work was done by the experiment station of the Minnesota University School of Mines. In connection with this experimental work, two new types of wet magnetic separators were developed by the experiment station. On account of the favorable features of ordinary log washers in use on other types of Minnesota ore, magnets were attached to the bottom for use on this class of material. This machine, which is called a magnetic log washer, has been tried out in a very exhaustive series of tests and produces high-grade concentration and low tailings at a high capacity. The other type mentioned consists of a wash trommel with magnets attached to the outside of the drum.

Beneficiation plants in operation in the Lake Superior region (except crushers).

Plant.	Operating company.	Range.	Equipment.	Rated capacity (20 hours) in tons.	Location.	Date of operation.	Character of ore.
Pewabic [a]	Pewabic Mining Co	Menominee	Crushes, screens, jigs		Iron Mountain, Mich.	1899	Hard hematite in sandstone.
Port Arthur [b]	Atikokan Iron Co		Roaster		Port Arthur, Ontario	1907	Sulphurous magnetite.
Jones Process [a]		Menominee	Rotary kiln, etc		Iron Mountain, Mich.	1908	Lean siliceous hematite.
Moose Mountain	Moose Mountain (Ltd.)	Moose Mountain	Coarse crushers, dry magnetic separators (cobbers).		Sellwood, Ontario	1908	Lean magnetite.
Coleraine	Oliver Iron Mining Co.	Mesabi	Screen, picking belts, log washers, turbos, Overstrom tables.	35,000	Coleraine, Minn	1910	Sandy hematite.
Mayville	Northwestern Iron Co.	Mayville	Grondal briquetting kilns, etc		Mayville, Wis	1911	Fine hematite (and flue dust).
Hollister [a]	M. A. Hanna Co	Menominee	Rotary dryers (Atlas Dryer Co.)	400	Crystal Falls, Mich	1912	Moist hematite.
Brunt	M. A. Hanna Co	Mesabi	Rotary dryers	2,400	Mountain Iron, Minn.	1912	Moist hematite.
Jones Process [a]		Marquette	Bruckner rotary kilns, etc		Republic, Mich	1912	Lean siliceous hematite.
Hawkins	International Harvester Co.	Mesabi	Screens, picking belt, [a] log washers, turbos.	5,000	Nashwauk, Minn	1912	Sandy hematite.
Moose Mountain	Moose Mountain (Ltd.)	Moose Mountain	Crushers, rolls, ball and pebble mills, wet magnetic separators, briquetting kilns.		Sellwood, Ontario	1912	Lean magnetite.
Madrid [b]	A. B. Coates	Mesabi	Screen, log washer, Wetherbee separator	300–500	Virginia, Minn	1912	Sandy hematite.
Magpie	Algoma Steel Co	Michipicoten	Crushers, rotary kilns	500–600	Magpie, Ontario	1913	Carbonate.
La Rue	M. A. Hanna Co	Mesabi	Screens, log washer, Wetherbee separator	1,500	Nashwauk, Minn	1913	Sandy hematite.
American-Boston	M. A. Hanna Co	Marquette	Crushers, screens, Woodbury jigs, Deister & Overstrom tables.	1,000	Diorite, Mich	1913	Lean decomposed banded chert and hematite.
Whiteside	Shenango Furnace Co.	Mesabi	Rotary dryers	2,400	Buhl, Minn	1913	Moist hematite.
Jones Process [a]		Marquette	Shaft-type furnace, etc		Marquette, Mich	1914	Lean siliceous hematite.
Quinn-Harrison	Butler Bros	Mesabi	Screens, picking belt, log washers, turbos, Overstrom tables.	5,000	Nashwauk, Minn	1915	Sandy hematite.
Crosby	Cleveland Cliffs Iron Co.	Mesabi	Screens, picking belt, log washers, turbo, tables.	2,000	Nashwauk, Minn	1915	Sandy hematite.
Thompson	Inland Steel Co	Cuyuna	Screens, picking belt, log washers, turbo	2,000	Crosby, Minn	1915	Sandy hematite.
Rowe	Pittsburgh Steel Ore Co.	Cuyuna	Crushers, screens, picking belt, log washers, tables.	5,000	Riverton, Minn	1915	Sandy and cherty hematite.
Cuyuna-Sultana	Cuyuna-Sultana	Cuyuna	Crusher, screen, picking belt, log washer		Ironton, Minn	1915	Manganiferous hematite.

[a] Abandoned.

[b] Not in operation in 1915.

As noted elsewhere, crushing of ore has been employed since the opening of the region, at first crudely by hand and later by mechanical means. At the present time the ore from more than 50 mines in the Lake region is crushed.

Crushing plants in operation in Lake Superior region.

Plant.	Operating company.	Range.	Location.
Section 30	Section 30 Mining Co	Vermilion	Section 30 Post Office, Minn.
Soudan	Oliver Iron Mining Co	Vermilion	Soudan, Minn.
Biwabik	Tod-Stambaugh Co.	Mesabi	Biwabik, Minn.
Brunt	Pittsburgh Iron Ore Co.	Mesabi	Mountain Iron, Minn.
Virginia		Mesabi	Virginia, Minn.
Palms	Dunn Iron Mining Co	Gogebic	Bessemer, Mich.
Antoine (formerly Traders).	Oglebay, Norton & Co.	Menominee	Iron Mountain, Mich.
Armenia	Corrigan, McKinney & Co.	Crystal Falls, Menominee.	Armenia, Mich.
Baker	Corrigan, McKinney & Co.	Iron River, Menominee.	Stambaugh, Mich.
Baltic	Verona Mining Co. (Pickands, Mather & Co.).	Iron River, Menominee.	Palatka, Mich.
Bengal	Verona Mining Co. (Pickands, Mather & Co.).	Iron River, Menominee.	Stambaugh, Mich.
Bristol (formerly Claire).	Bristol Mining Co. (Oglebay, Norton & Co.).	Crystal Falls, Menominee.	Crystal Falls, Mich.
Buckeye	Reserve Mining Co. (Oglebay, Norton & Co.).	Florence, Menominee.	Commonwealth, Wis.
Calumet	Calumet Ore Co. (Pickands, Mather & Co.).	Felch Mountain, Menominee.	
Caspian	Verona Mining Co. (Pickands, Mather & Co.).	Iron River, Menominee.	Caspian, Mich.
Chatham	Brule Mining Co. (Oglebay, Norton & Co.).	Iron River, Menominee.	Iron River, Mich.
Chicagon	Munro Iron Mining Co	Iron River, Menominee.	
Crystal Falls	Corrigan, McKinney & Co.	Crystal Falls, Menominee.	Crystal Falls, Mich.
Cundy	Oliver Iron Mining Co.	Menominee	Quinnesec, Mich.
Dunn	Corrigan, McKinney & Co.	Crystal Falls, Menominee.	Crystal Falls, Mich.
Fairbanks, or Paint River.	Corrigan, McKinney & Co.	Crystal Falls, Menominee.	Crystal Falls, Mich.
Florence	Florence Iron Co. of Wisconsin	Florence, Menominee.	Florence, Wis.
Fogarty	Verona Mining Co. (Pickands, Mather & Co.).	Menominee	Palatka, Mich.
Genesee	Corrigan, McKinney & Co.	Crystal Falls, Menominee.	Crystal Falls, Mich.
Great Western	Corrigan, McKinney & Co.	Crystal Falls, Menominee.	Crystal Falls, Mich.
Groveland		Menominee	
Chase	Cleveland-Cliffs Iron Co.	Marquette	5 miles west of Ishpeming, Mich.
Cliff Shaft	The Iron Cliffs Co.	Marquette	Ishpeming, Mich.
Empire	Empire Iron Co.	Marquette	Palmer, Mich.
Moro	Cleveland-Cliffs Iron Co.	Marquette	Ishpeming, Mich.
North Jackson	The Jackson Iron Co.	Marquette	Negaunee, Mich.
Republic	Cleveland-Cliffs Iron Co.	Marquette	Republic, Mich.
Richmond	Richmond Iron Co.	Marquette	Palmer, Mich.
South Jackson	The Jackson Iron Co.	Marquette	Negaunee, Mich.
Star West	Corrigan, McKinney & Co.	Marquette	Palmer, Mich.
Washington	Washington Iron Co.	Marquette	Humboldt, Mich.
Helen	Algoma Steel Corp. (Ltd.)	Michipicoten	Michipicoten district, Ontario.
Hemlock	Hemlock River Mining Co.	Crystal Falls, Menominee.	Amasa, Mich.
Hiawatha	Munro Iron Mining Co	Iron River, Menominee.	Iron River, Mich.
Hill Top and Victoria.	Cuyahoga Mining Co	Crystal Falls, Menominee.	Crystal Falls, Mich.
Judson	Judson Mining Co.	Crystal Falls, Menominee.	Judson, Mich.
Kimball	Corrigan, McKinney & Co.	Crystal Falls, Menominee.	Crystal Falls, Mich.
Lamont		Crystal Falls, Menominee.	Crystal Falls, Mich.
Lincoln	Corrigan, McKinney & Co.	Crystal Falls, Menominee.	Crystal Falls, Mich.
Munro	Munro Iron Mining Co	Menominee	Quinnesec, Mich.
Ohio	Niagara Iron Mining Co	Marquette	Michigamme, Mich.

Crushing plants in operation in Lake Superior region—Continued.

Plant.	Operating company.	Range.	Location.
Quinnesec	Corrigan, McKinney & Co	Marquette	Quinnesec, Mich.
Ravenna	The Hollister Mining Co	Crystal Falls, Menominee.	Crystal Falls, Mich.
Riverton	Oliver Iron Mining Co	Iron River, Menominee.	Caspian, Mich.
Rogers	Munro Iron Mining Co	Iron River, Menominee.	Rogers, Mich.
Tobin	Corrigan, McKinney & Co	Crystal Falls, Menominee.	Crystal Falls, Mich.
Tully	Corrigan, McKinney & Co	Iron River, Menominee.	Iron River, Mich.
Vivian	Verona Mining Co	Menominee	Quinnesec, Mich.
Zimmerman	Spring Valley Iron Co	Iron River, Menominee.	Palatka, Mich.

METHODS OF TREATMENT.

From the description of these crushing plants it will be seen that several methods are in use commercially or experimentally in the Lake Superior region at the present time. The largest tonnage is treated by crushers, log washers, or similar machines, but some ore is jigged, some is dried, and some is calcined.

The character of material treated is exceedingly varied, and it is impossible here to give actual results of treatment. The "washing plants" seldom treat sandy ore below 40 per cent iron (dry), and they generally recover 60 to 75 per cent of the ore in the form of concentrates. These concentrates carry from 55 to 60 per cent iron (dry). These figures depend almost entirely on the character of the ore.

EFFECT OF CHARACTER OF MATERIAL ON BENEFICIATION.

In order to understand the reasons for the difference in the character of the concentrating plants already described, it is essential to consider the character of the various low-grade iron-bearing materials of the Lake Superior region.

The productive Lake Superior iron formations are sedimentary in character. They were probably laid down originally either as cherty iron carbonates or as hydrous ferrous silicates and iron oxide. The conditions of deposition varied from time to time, giving rise to a banded formation consisting alternately of siliceous layers and layers mainly composed of iron minerals, or some gradation between the two.

Secondary concentration was effected by surface waters which first oxidized and hydrated the iron carbonate and silicate. Then silica was leached out along channels of circulation. When this leaching had progressed nearly to completion, the high-grade ore bodies resulted which have produced the direct shipping ores on the several ranges.

By far the largest quantity of the iron-bearing formation has been more or less imperfectly acted upon by these processes of secondary concentration. Such material constitutes all but one class of the so-called low-grade iron-bearing material. The exceptions are the titaniferous magnetites of Cook and Lake counties, Minn., which appear to be magmatic segregations in the Duluth gabbro.

A large factor in the retardation of secondary concentration seems to have been metamorphism by heat, pressure, or both. This presumably occurred while the iron was largely in the ferrous condition and produced the magnetic oxide of iron, and other mineral constituents, which withstood the further solvent action of the surface waters. Examples of this type of material are found abundantly on the eastern Mesabi range, the Gunflint district, the western Gogebic range, and at certain points on the western Marquette range, such as at the Michigamme mine. In other places, where this metamorphic action has not taken place, leaching proceeded very slowly or not at all. As a result, we have, to-day, relatively hard banded material consisting of layers of more or less siliceous hematite, sometimes containing considerable molecular water, and layers of relatively hard unleached cherty silica or rock. Examples of material of this character are the solid or partially decomposed taconite of the western Mesabi range, the relatively hard cherty ores of the Cuyuna and Gogebic ranges, and the banded jasper and ore of the Vermilion and Marquette ranges.

When leaching had progressed farther than in the class of material just mentioned, but had not been entirely completed, we find what is termed, locally, "sandy ore." Such material consists of alternate bands of more or less siliceous, hydrated hematite interlayered with fine sand. The sand has resulted from the disintegration of the hard cherty bands, but has not been entirely removed. Examples of this type of material are found in the ore bodies of the western Mesabi range, lying principally west of Nashwauk and in minor quantities throughout the central Mesabi and on the Cuyuna range.

The discussion so far has been limited to materials which are low in iron on account of large percentages of silica. Other impurities occur in Lake Superior iron-bearing material, which either render them too low in iron to be shipped direct or else undesirable for furnace use. These impurities are principally phosphorus, sulphur, titanium, alumina, and moisture.

Phosphorus occurs in greater or less quantity in all Lake Superior iron-bearing material. Its presence above certain limits causes a penalty to be imposed by the furnace men. Sulphur occurs as sulphide of iron and as hydrous calcium sulphate at certain places in prohibitive quantities. Titanium occurs in the so-called titaniferous magnetites of northeastern Minnesota. Its presence presents blast-furnace difficulties. Alumina occurs in the so-called "paint rocks" of the Mesabi and other ranges. Although the iron content is relatively high, difficulties arising in the blast furnace prevent its use at the present time.

Moisture is present in greater or less quantity in all the ores; in some ores it runs as high as 16 or 18 per cent. This is often sufficient to lower the "natural iron" content below the merchantable limit, and high transportation rates from the Lake region to the furnaces prohibit the shipment of such large quantities of water per unit of recoverable iron.

As has already been shown, interest in the mechanical improvement or beneficiation of Lake ores dates back to small beginnings nearly 30 years ago. On account of the great draft upon the reserves of the high-grade ores, it is a subject of considerable importance at

the present time. It will therefore be of interest to review the various methods of beneficiation now available.

It is evident that the character of treatment will depend on the type of material under discussion and on the impurity to be removed. In general, the following principles of "beneficiation" will be found applicable either at the present time or at some future date for low-grade iron-bearing material of the Lake region.

Thermal processes.—(*a*) Drying—removes ordinary moisture and some combined water and is employed to facilitate the removal of clay, rock, and sand.

(*b*) Calcining—removes carbon dioxide from iron carbonates, combined water from hydrated hematites, and ordinary moisture. Under proper conditions the magnetic oxide is produced.

(*c*) Roasting—removes sulphur, carbon dioxide, combined water, and ordinary moisture.

(*d*) Agglomerating—used primarily for the purpose of preparing finely divided material for the blast furnace. Includes briquetting, sintering, and nodulizing. Removes sulphur, carbon dioxide, combined water, and ordinary moisture.

(*e*) Metallizing—reduces iron oxide to metallic iron without eliminating gangue. Incidentally accomplishes all that (*a*), (*b*), and (*c*) accomplish.

Mechanical processes—(*a*) Hand sorting—to remove coarse rock.

(*b*) Crushing—reduces ore to size suitable for blast-furnace use, and is also used preliminary to other mechanical processes.

(*c*) Screening—removes large pieces of rock and fine sand.

(*d*) Classification—removes sand by means of currents of water of varying velocities.

(*e*) Log washing—removes fine sand.

(*f*) Jigging—removes larger particles of gangue than is possible by log washing. Certain types of jigs remove fine sand.

(*g*) Reciprocating tables—recover fine iron mineral from sands discarded by the processes named above.

(*h*) Magnetic separation—applicable to the commercial separation of the magnetic oxide of iron from gangue material. It is possible, but not commercially practicable, magnetically to separate certain hematites and limonites from their gangue.

(*i*) Miscellaneous processes—comprise dry concentration, electrostatic separation, flotation, and other processes which have been applied with more or less success to material of certain districts.

Certain materials may be of such character that a single simple operation may suffice to beneficiate them; others may require more complicated treatment, involving several methods.

From a technical standpoint, what can be accomplished by beneficiation will depend on the physical and chemical character of the impurity to be removed. In the sandy ores, silica in the form of fine sand can be largely removed by log washing. The bands of ore which are relatively soft and, on mining, break down into relatively small lumps, contain a certain amount of silica very intimately associated with the iron oxide. This can be readily seen in a thin section under the microscope, occurring as particles a thousandth of an inch in diameter or less. Silica, in this form, can not be separated com-

mercially from the hematite by mechanical means. Consequently, the grade of concentrates produced by log washing sandy ore or by jigging harder cherty ore will depend almost entirely on the grade of the bands or lumps of ore. These in turn depend on the original iron content and on the amount of microscopic silica that has been removed by secondary leaching.

In magnetic ores there is microscopic silica in the ore bands and microscopic particles of magnetite in the gangue bands. Also there are certain silicates of iron in the gangue which are nonmagnetic, and in some localities, such as the western Gogebic, there is a certain proportion of specular hematite. With such material very fine grinding, 300 mesh and finer, will liberate a large proportion of the microscopic particles of gangue, and the microscopic particles of magnetite, which can then be recovered on account of their magnetic attraction. Iron occurring in this material, in the form of silicate or as hematite, naturally will largely be lost in the tailings. In general, with this material it may be said that the possible grade of the product will depend principally on the fineness of grinding.

The success of beneficiating low-grade iron-bearing material will depend not only on the grade of product and the recovery of concentrates that can be made, but on the cost of the finished product. Conditions are still governed by the price of available direct shipping ores, and any beneficiated product must be produced at a cost that will compete on an even basis at the furnace. With the growing scarcity of high-grade ores higher prices will undoubtedly obtain and more expensive beneficiation treatment will be justifiable.

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FOREIGN TRADE IN IRON ORE.

IMPORTS.

The quantity of iron ore imported into the United States in 1915 was 1,341,281 gross tons, valued at $4,181,645, or $3.12 a ton. This represents a decrease in quantity of 9,307 tons, or 0.7 per cent, and in value of $302,187, or 7 per cent, as compared with the imports during 1914, which were 1,350,588 gross tons, valued at $4,483,832, or $3.32 a ton. As to the source of the imports in 1915, Cuba produced approximately 60 per cent of the ore, Sweden 15 per cent, Chile 11 per cent, Canada 6 per cent, Spain 3 per cent, with minor quantities from French Africa, Egypt, Greece, and other countries. The imports from Chile doubtless would have been much greater had not the Panama Canal been closed for a long period by earth slides. Supplies from the United Kingdom, Germany, the Netherlands, and Belgium were wholly interrupted in 1915 by war, and it is probable that the imports from Newfoundland, which diminished greatly in 1914 and ceased altogether in 1915, have been diverted to England. Supplies from Canada, however, increased in volume in 1915, largely from the Canadian ranges in the Lake Superior region.

The statistics of imports of iron ore are compiled from the records of the Bureau of Foreign and Domestic Commerce.

Iron ore imported into the United States, 1912–1915.

Country.	1912		1913		1914		1915	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Cuba	1,398,593	$3,969,986	1,635,622	$4,864,186	815,017	$2,288,102	831,618	$2,450,163
Spain	92,061	222,951	112,580	488,798	66,982	233,287	42,092	165,827
French Africa	.....	.....	12,950	32,299	46,175	114,781	21,825	47,272
Greece	.....	.....	9,200	12,952	.....	.....	738	2,895
Newfoundland and Labrador	145,355	217,087	213,468	325,230	38,515	57,681	.....	.....
United Kingdom	10,229	20,587	10,431	24,726	2,663	52,814	.....	.....
Germany	1,729	5,602	1,323	6,223	2,256	9,222	.....	.....
Netherlands	5	72	.....	.....	.....	.....	.....	.....
Canada	106,675	201,882	179,860	409,098	52,514	153,415	84,124	245,092
Belgium	.....	.....	6	30	.....	.....	.....	.....
Russia in Europe	3,916	16,709	.....	.....	.....	.....	.....	.....
Sweden	333,863	1,781,579	356,074	1,901,988	280,887	1,481,747	204,632	1,061,624
Chile	.....	.....	.....	.....	35,180	41,760	153,600	181,271
Other countries	12,150	63,235	[a] 63,256	[a] 271,289	[b] 10,399	[b] 51,023	[c] 2,652	[c] 27,501
	2,104,576	6,499,690	2,594,770	8,336,819	1,350,588	4,483,832	1,341,281	4,181,645

[a] Of this, 57,225 tons, valued at $216,852, was from Venezuela and 4,400 tons, valued at $16,718, was from Egypt.
[b] Of this, 2,400 tons, valued at $3,600, was from Venezuela, and 6,050 tons, valued at $40,039, was from French Oceania.
[c] Of this, 2,638 tons, valued at $27,280, was from Egypt.

In the following table are shown the annual imports of iron ore into the United States as far as recorded. Iron ore was imported from Europe in large quantities for the first time in 1879, most of the imports prior to that date coming from Canada.

Iron ore imported into the United States, 1872–1915, in gross tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1872	23,733	1887	1,194,301	1903	980,440
1873	45,981	1888	587,470	1904	487,613
1874	57,987	1889	853,573	1905	845,651
1875	56,655	1890	1,246,830	1906	1,060,390
1876	17,284	1891	912,864	1907	1,229,168
1877	30,669	1892	806,585	1908	776,898
1878	28,212	1893	526,951	1909	1,694,957
1879 [a]	150,197	1894	167,307	1910	2,591,031
1879 [b]	284,141	1895	524,153	1911	1,811,732
1880	493,408	1896	682,806	1912	2,104,576
1881	782,887	1897	489,970	1913	2,594,770
1882	589,655	1898	187,208	1914	1,350,588
1883	490,875	1899	674,082	1915	1,341,281
1884	487,820	1900	897,831		
1885	390,786	1901	966,950		35,723,169
1886	1,029,433	1902	1,165,470		

[a] Fiscal years end. [b] Calendar years begin.

EXPORTS.

The quantity of iron ore exported from the United States in 1915 amounted to 707,641 gross tons, valued at $2,181,629, or $3.08 a ton, as compared with 551,618 gross tons, valued at $1,794,193, or $3.25 a ton, in 1914. This represents an increase in quantity of 156,023 tons, or 28 per cent, and in value of $387,436, or 22 per cent.

The data regarding exports are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce.

Iron ore exported from the United States, 1899–1915, in gross tons.

Year.	Quantity.	Year.	Quantity.
1899	40,665	1909	455,934
1900	51,460	1910	748,875
1901	64,703	1911	768,386
1902	88,445	1912	1,195,742
1903	80,611	1913	1,042,151
1904	213,865	1914	551,618
1905	208,017	1915	707,641
1906	265,240		
1907	278,608		7,071,060
1908	309,099		

IRON-ORE INDUSTRY OF CUBA.

The iron ore shipped from Cuba in 1915 amounted to 827,448 gross tons, valued at $2,859,900, compared with 821,110 gross tons, valued at $2,378,130 in 1914, an increase in quantity of 6,338 tons, or 0.8 per cent, and in value of $481,770, or 20 per cent. The shipments in 1915 consisted of 64 per cent of hematite, including a little magnetite, and 36 per cent of brown ore. The iron content of the hematite,

dried at 212° F., ranged from 57 per cent to 60.05 per cent, and the brown ore carried 36.32 per cent (natural) and 56.30 per cent (nodulized). The total stock of ore reported as on hand at the close of 1915 was 470,544 gross tons, compared with 564,393 tons at the close of 1914. This included both natural and nodulized ore.

The following table shows the shipments of iron ore from Cuba since the opening of the mines in 1884. The statistics of the Cuban iron-ore shipments are collected by the United States Geological Survey.

Iron ore shipped from mines in the Province of Oriente (Santiago), Cuba, 1884–1915, in gross tons.

Year.	Juragua Iron Co. (Ltd.) (hematite and magnetite).	Sigua Iron Co. (hematite).	Spanish-American Iron Co.		Cuban Steel Ore Co. (hematite).	Ponupo Manganese Co., El Cuero iron mines (hematite).	Total.
			Daiquiri mines (hematite and a little magnetite).	Mayari mines (brown ore).			
1884	25,295						25,295
1885	80,716						80,716
1886	112,074						112,074
1887	94,240						94,240
1888	206,061						206,061
1889	260,291						260,291
1890	363,842						363,842
1891	264,262						264,262
1892	335,236	6,418					341,654
1893	337,155	14,020					351,175
1894	156,826						156,826
1895	307,503		74,991				382,494
1896	298,885		114,110				412,995
1897	[a] 248,256		[b] 206,029				454,285
1898	83,696		80,225				163,921
1899	161,783		211,442				373,225
1900	154,871		293,195				448,066
1901	199,764		[c] 334,974		17,651		552,389
1902	221,039		455,105		23,590		699,734
1903	155,898		467,629				623,527
1904	31,162		356,111				387,273
1905	139,828		421,331				561,159
1906	133,379		507,195				640,574
1907	181,063		469,111				650,174
1908	366,580		254,256				620,836
1909	356,659		519,752			59,721	936,132
1910	318,814		670,976	307,700		165,008	1,462,498
1911	355,132		252,717	387,791		168,074	1,163,714
1912	360,094		463,533	446,176		127,994	1,397,797
1913	369,213		591,322	491,713		130,183	1,582,431
1914	267,641		284,507	228,949		40,013	821,110
1915	215,032		245,590	300,896		65,930	827,448
	7,162,290	20,438	7,274,101	2,163,225	41,241	756,923	17,418,218

[a] Of this quantity, 5,932 tons were sent to Pictou, Nova Scotia.
[b] Of this quantity, 51,537 tons were sent to foreign ports.
[c] Of this quantity, 12,691 tons were sent to foreign ports.

PRODUCTION OF IRON ORE IN PRINCIPAL COUNTRIES.

The latest available statistics of production of iron ore in the principal producing countries beginning with 1911 are given in the accompanying table.

The figures are taken from the official publications of the following countries: Belgium, Canada, France, German Empire and Luxemburg, India, Italy, Spain, and the United Kingdom. The figures for Algeria and Tunis are taken from the official publication of the French Government; those for Cuba are collected by the United States Geological

Survey; and those for the Philippine Islands are derived from the report of the Bureau of Mines, Manila, P. I. Otherwise, Mines and Quarries (the official British publication), London, is used. The Geological Survey also receives assistance in its foreign statistics from Mineral Industry, New York.

In the original publications the statistics of many of the countries are given in metric tons, but these have for the sake of comparison been reduced to gross tons.

Iron ore produced in principal countries, 1911–1915, in gross tons.

Country.	1911	1912	1913	1914	1915
North America:					
Canada[a]	187,807	192,753	274,673	218,620	355,457
Cuba[a]	1,163,714	1,397,797	1,582,431	821,110	827,448
Newfoundland	1,171,992	1,251,968	(b)	(b)	(b)
United States	43,876,552	55,150,147	61,980,437	41,439,761	55,526,490
South America:					
Chile	28,150	6,349	(b)	(b)	(b)
Europe:					
Austria-Hungary	4,779,851	4,997,311	5,018,109	(c)	(b)
Belgium	148,130	164,734	(b)	(b)	(b)
France	16,376,967	18,858,668	21,572,835	(b)	(b)
German Empire and Luxemburg	29,408,812	33,180,258	[d] 26,771,598	(b)	(b)
Greece	493,106	424,835	305,195	294,573	(b)
Italy	367,900	572,900	593,618	695,124	(b)
Norway	217,051	401,665	77,693	(b)	(b)
Portugal	19,233	28,947	48,407	(b)	(b)
Russia	(e)	(e)	(b)	(b)	(b)
Spain	8,635,523	[f] 8,990,743	9,706,366	(b)	(b)
Sweden	6,056,868	6,595,044	7,357,845	6,482,904	(b)
United Kingdom	15,519,424	13,790,391	15,997,328	14,867,582	(b)
Asia:					
China[g]	109,542	201,561	269,748	(b)	(b)
Chosen (Korea)	96,902	121,224	(b)	(b)	(b)
India	366,190	580,224	370,845	441,674	(b)
Japan	(h)	(h)	(b)	(b)	(b)
Philippine Islands	216	347	546	392	(b)
Africa:					
Algeria	1,057,087	1,171,252	(b)	(b)	(b)
Madagascar	(i)	22	(b)	(b)	(b)
Togoland	394	(b)	(b)	(b)	(b)
Tunis	397,638	470,866	(b)	(b)	(b)
Australia	122,361	113,989	(j)	(j)	(k)

[a] Shipments.
[b] Statistics not available.
[c] Statistics not available. Bosnia and Herzegovina produced 176,014 gross tons.
[d] Germany alone. Figures not available for Luxemburg.
[e] Russia produced 3,536,417 gross tons of pig iron in 1911 and 4,131,890 tons in 1912.
[f] Includes 1,563 gross tons argentiferous iron ore, value $8,307.
[g] Exports.
[h] Japan produced 52,223 gross tons of pig iron in 1911 and 55,379 tons in 1912.
[i] Madagascar produced 1.5 tons of iron (metal) in 1911.
[j] Queensland produced 40,838 gross tons and South Australia 60,658 tons in 1913; in 1914, Queensland 48,090 and South Australia 42,622 tons.
[k] Queensland produced 45,686 gross tons.

STATISTICS OF BENEFICIATED IRON ORE.

Statistics of beneficiated iron ore were gathered by the Survey for the first time during the canvass for the year 1914 and, although it is not believed that complete returns were received from every producer who subjects his ore to any form of beneficiation, the responses to the special inquiries were, on the whole, satisfactory and interesting, and they showed continued improvement in 1915.

The following processes were reported as employed to improve the quality of the ore at various mines: Crushing and screening, drying by direct heat and by steam, hand picking on tables and on belts, washing by means of hydraulic jets and logs, jigging, electromagnetic

cobbing, other concentration and separation, calcining, nodulizing, and desulphurization by sintering. Iron ores were reported as beneficiated at 66 mines in 14 States, besides at the brown-ore mines of the Spanish-American Iron Co. in Cuba.

In Alabama the ore treated was brown ore, and the usual process to which it was subjected was log washing. A total of 744,193 gross tons of beneficiated brown ore, valued at $1,278,344, was marketed from nine mines in Alabama in 1915, compared with 641,817 tons, valued at $955,035, in 1914.

One mine in Connecticut, five in Georgia, two in Maryland, one in Massachusetts, and one in Missouri reported the concentration of brown ore in 1915.

Red hematite was beneficiated at 3 mines in Michigan and at 13 mines in Minnesota. Washing and drying were the principal processes employed, and 2 mines reported crushing and running over picking belt in 1915.

Three mines reported magnetic concentration of magnetite in New Jersey, and at one of them a "dry table" was employed in addition; two mines reported hand cobbing. At one mine in North Carolina, which produces magnetite, the ore was subjected to a rough concentration consisting of electromagnetic cobbing, and one mine reported washing of brown ore in 1915.

In New York beneficiation of ore was reported by eight mines. One of these mines produced red hematite, which was crushed and picked on a belt; one mine washed brown ore; and the rest produced magnetite. The magnetite was mainly concentrated magnetically, although at one mine crushing and hand picking only was reported. The total shipments of beneficiated hematite and magnetite in New York amounted to 685,032 gross tons, valued at $2,055,143, in 1915, compared with 519,743 tons, valued at $1,567,753, in 1914.

One mine in Pennsylvania reported washing and screening red hematite in revolving screens; two mines reported washing brown ore; at one mine the Gröndal concentrating process was employed; and one magnetite mine reported desulphurization by sintering. The shipments of beneficiated ore from this State amounted to 162,253 gross tons, valued at $422,264, in 1915, compared with 157,920 tons, valued at $337,295, in 1914.

In Tennessee red hematite from the mines of the Rockwood-Cardiff area was improved by breaking and hand picking, and brown ore from two mines in the west-central belt was beneficiated. At one of these brown-ore mines washing was reported as the only method; the other reported hand picking, washing, and jigging. In all probability, however, hand picking is employed to a greater or less extent at nearly all brown-ore mines where the ore is mixed with gravel. Calcining of brown ore is practiced at one cold-blast furnace. The total beneficiated iron ore shipped from mines in Tennessee in 1915 was 167,844 gross tons, valued at $207,936, compared with 183,780 tons, valued at $249,422, in 1914.

Five mines reported beneficiation of brown ore in Virginia in 1915, one reporting magnetite washed. The total shipments of treated ore were 155,956 gross tons, valued at $343,045. Washing, screening, and jigging were the methods employed in treating this ore.

The brown ores of Mayari Province, Cuba, have been nodulized for many years at an extensive plant on Nipe Bay. The total

quantity of this ore reported as shipped in 1915 amounted to 296,279 gross tons, compared with 215,883 tons in 1914.

The total beneficiated ore reported as shipped from mines in the United States in 1915 amounted to 5,581,029 gross tons, valued at $11,401,846, compared with 4,130,298 tons, valued at $8,000,807, in 1914. It was hoped that the statistics reported might contain more complete figures that would show the relation between crude ore treated and beneficiated ore recovered. These figures, however, were rather fragmentary, owing to the fact that at most brown-ore mines and many red-ore mines only the resultant cleaned ore is weighed. The most complete figures submitted were those for red hematite. From such figures as are available, however, it is apparent that in washing brown ore the ratios, by weight, of crude ore washed to resultant concentrates range from 5:1 to 1.08:1; in concentrating red hematite, the ratios range from 1.98:1 to 1.01:1; and in magnetite they range from 2.74:1 to 1.08:1.

Beneficiated iron ore shipped from mines in the United States, 1914 and 1915.

State.	Variety.	1914		1915	
		Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Alabama	Brown ore	641,817	$955,035	744,193	$1,278,344
Georgia	do	(a)	(a)	61,602	119,634
Michigan	Red hematite	(a)	(a)	140,862	205,359
Minnesota	do	2,119,838	3,642,457	3,030,549	5,572,845
New Jersey	Magnetite	197,098	622,100	360,325	1,049,530
New York	Red hematite, Brown ore, Magnetite	519,743	1,567,753	685,032	2,055,143
Pennsylvania	Red hematite, Brown ore, Magnetite	157,920	337,295	162,253	422,264
Tennessee	Red hematite, Brown ore	183,780	249,422	167,844	207,936
Virginia	Brown ore, Magnetite	158,227	335,890	155,956	343,045
Other States[b]	Red hematite, Brown ore, Magnetite	151,875	290,855	72,413	147,746
		4,130,298	8,000,807	5,581,029	11,401,846

[a] Included in "Other States."
[b] 1914: Connecticut, Georgia, Massachusetts, Michigan, and North Carolina; 1915: Connecticut, Massachusetts, Missouri, and North Carolina.

IRON AND STEEL.[1]

PRODUCTION, SHIPMENTS, AND VALUE OF PIG IRON, BY STATES.

Commenting on conditions in the iron industry in 1915, the Iron Trade Review[2] says:

Last year will always rank as one of the most unusual in American pig iron history. Opening with the number of active furnaces at the lowest level in years, it closed with last month [December, 1915], establishing a new high-water mark in pig-iron production. No stronger demonstration of the marvelous recuperative powers of the iron and steel industry in meeting unexpected and unprecedented demand could be afforded.

[1] The statistics for all production of steel and the statistics for pig iron prior to 1912, except those of sales of pig iron, were published in the annual reports of the American Iron and Steel Association; beginning with 1912, they have been furnished by the bureau of statistics of the American Iron and Steel Institute.
[2] December iron output sets record: Iron Trade Rev., Jan. 6, 1916, p. 48.

The bureau of statistics of the American Iron and Steel Institute reports the production in 1915 of all kinds of pig iron, including such ferroalloys as spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus, produced in blast furnaces, as well as some that were electrically produced, as 29,916,213 gross tons, compared with 23,332,244 tons produced in 1914, an increase of 6,583,969, or 28 per cent.

The United States Geological Survey regards as official the statistics of production of pig iron and ferroalloys now published by the American Iron and Steel Institute; but it has been found necessary for the Survey also to make a statistical canvass of the pig-iron manufacturing industry in order to obtain the value of the product, the data for which can be obtained in no other way. It should be explained here that the only common term in which the production of diversified mineral products may be expressed is that of value—at mine, quarry, or manufacturing plant—and in order that the mineral production of the United States may be summarized the value of each product must be obtained. It has been found more accurate and practical, as well as convenient, to obtain the value of the pig iron corresponding to the quantity sold or used rather than that corresponding to the actual production by the furnaces in a given year, and thus in collecting and publishing the statistics of quantity and value of shipments of pig iron the Survey is not duplicating the labors of the American Iron and Steel Institute, but, instead, is presenting additional data to the iron trade—data that are available by the Survey alone.

The following table gives the total production of pig iron, in 1914 and 1915, by States, according to their rank each year:

Pig iron manufactured in the United States in 1914 and 1915, in gross tons.[a]

1914		1915	
State.	Quantity (gross tons).	State.	Quantity (gross tons).
Pennsylvania	9,733,369	Pennsylvania	12,790,668
Ohio	5,283,426	Ohio	6,912,962
Illinois	1,847,451	Illinois	2,447,220
Alabama	1,826,929	New York	2,104,780
New York	1,559,864	New Jersey	
New Jersey		Alabama	2,049,453
Indiana	1,557,355	Indiana	1,986,778
Michigan		Michigan	
Wisconsin	329,526	Wisconsin	372,966
Minnesota		Minnesota	
Virginia	271,228	West Virginia	291,040
Missouri	267,777	Kentucky	
Colorado		Mississippi	
California		Missouri	271,921
West Virginia	236,393	Colorado	
Kentucky		California	
Mississippi		Maryland	251,548
Tennessee	216,738	Virginia	251,346
Maryland	195,594	Tennessee	177,729
Massachusetts	6,594	Connecticut	7,802
Connecticut		Massachusetts	
	23,332,244		29,916,213

[a] Bureau of statistics of the American Iron & Steel Institute. Includes some ferroalloys

According to reports to the United States Geological Survey by the manufacturers the shipments of pig iron, exclusive of ferroalloys, in 1915 amounted to 30,384,486 gross tons, valued f. o. b. at the furnaces at $401,409,604, as compared with 22,263,263 tons, valued at $298,777,429, in 1914, an increase in quantity of 8,121,223 tons, or 36 per cent, and in value of $102,632,175, or 34 per cent. The average price per ton in 1915 was $13.21, and in 1914 it was $13.42, a decrease in 1915 of $0.21 a ton. These values represent the approximate price per ton f. o. b. at the furnaces; this approximate price eliminates freight costs, selling commissions, and other items, which are included in the market prices of certain grades of pig iron as published in the trade journals.

The pig iron shipped includes the metal produced from foreign as well as from domestic ore. The quantity and value of pig iron derived from ore imported from Africa, Brazil, Canada, Chile, Cuba, Newfoundland, Spain, and Sweden, although it constitutes a very small percentage of the total production, is considerable, as the shipments of this metal, derived from foreign ore, amounted in 1915 to 945,022 gross tons, valued at $13,011,950, as compared with 803,411 tons, valued at $11,464,635, in 1914. In the manufacture in 1915 of 910,595 gross tons of pig iron, 1,381,484 gross tons of foreign iron ore were reported to have been used, thus indicating an average pig-iron yield of 65.91 per cent as compared with the quantity of imported ore. Domestic ore, including 251,593 tons of cinder and scale, and amounting to 54,027,538 gross tons was reported in 1915 as used in the manufacture of 28,646,349 tons of pig iron, thus indicating a yield of 53.02 per cent in pig iron from the domestic ore.

Pig iron shipped from blast furnaces in the United States in 1914 and 1915.

State.	1914		1915		Increase in 1915.		Percentage of increase in 1915.	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity.	Value.
Alabama	1,661,420	$17,481,828	2,320,255	$23,757,124	658,835	$6,275,296	40	36
Illinois	1,793,714	21,382,458	2,455,894	34,207,901	662,180	9,825,443	37	40
Kentucky	57,687	706,120	105,700	1,420,275	48,013	714,155	83	101
Michigan	379,619	5,229,948	486,106	6,624,559	106,487	1,394,611	28	27
New York	1,357,575	19,353,309	2,010,076	28,178,466	652,501	8,825,157	48	46
Ohio	5,226,925	70,331,114	6,995,000	90,549,626	1,768,075	20,218,512	34	29
Pennsylvania	9,267,197	127,686,331	12,779,974	174,926,891	3,512,777	47,240,560	38	37
Tennessee	178,481	2,150,452	208,298	2,519,337	29,817	368,885	17	17
Virginia	197,981	2,481,197	265,616	3,408,784	67,635	927,587	34	37
Wisconsin	250,944	3,350,199	302,913	3,997,940	51,969	647,741	21	19
Other States[a]	1,891,720	25,624,473	2,454,654	31,818,701	562,934	6,194,228	30	24
	22,263,263	298,777,429	30,384,486	401,409,604	8,121,223	102,632,175	36	34

[a] 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, and West Virginia; 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

PRICES.

The average price of pig iron per gross ton, by States, from 1911 to 1915, given in the following table, is based on reports of the manufacturers to the Survey. These figures represent the prices at the blast furnaces and do not include the prices of blast-furnace ferroalloys.

The average prices for 1915 appear low for such an active year in the iron industry. Prices, however, did not revive as rapidly as production, and in the early months of the year orders were taken at low prices for delivery late in the year by many producers who did not clearly foresee the future possibilities. At the close of the year prices of pig iron had advanced 35 to 40 per cent above the average for the year.

Average price per gross ton of pig iron in the United States, 1911 to 1915.

State.	1911	1912	1913	1914	1915
Alabama	$10.75	$10.75	$12.08	$10.52	$10.24
Illinois	15.30	15.26	15.83	13.59	13.93
Kentucky	15.01	15.74	16.09	12.24	13.44
Michigan	15.34	14.30	14.69	13.78	13.63
New York	15.56	14.22	15.35	14.26	14.02
Ohio	13.68	13.07	15.02	13.46	12.96
Pennsylvania	14.23	14.60	15.36	13.78	13.69
Tennessee	11.56	12.29	13.22	12.05	12.09
Virginia	12.62	13.27	13.96	12.53	12.83
Wisconsin	15.51	14.33	15.13	13.35	13.20
Other States[a]	14.94	14.07	15.50	13.55	12.96
Average for United States	14.07	13.93	15.08	13.42	13.21

[a] 1911: California, Colorado, Connecticut, Georgia, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1912 and 1913: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia; 1914: California, Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Mississippi, Missouri, New Jersey, and West Virginia; 1915: Colorado, Connecticut, Indiana, Maryland, Massachusetts, Minnesota, Missouri, New Jersey, and West Virginia.

In the following summary of the annual average price per gross ton of pig iron in the United States for the years 1889 to 1915, the prices prior to 1907 include the cost of transportation of some pig iron from blast furnaces to markets. Prior to 1910 the values of blast-furnace ferroalloys are included. Since 1910 the prices represent, as closely as can be ascertained, the average price paid for pig iron at the blast furnaces. The extreme range in prices, from $9.76 in 1894 to $20.92 in 1902, is of interest. The lowest prices were in the years 1894 to 1898, and the highest were in the years 1902 to 1907.

Average price per gross ton of pig iron in the United States, 1889–1915.

1889	$15.78	1898	$9.90	1907	$20.56
1890	16.43	1899	18.00	1908	15.96
1891	15.50	1900	18.85	1909	16.25
1892	14.32	1901	15.25	1910	15.45
1893	11.90	1902	20.92	1911	14.07
1894	9.76	1903	19.12	1912	13.93
1895	11.14	1904	14.13	1913	15.08
1896	10.47	1905	16.63	1914	13.42
1897	9.85	1906	19.98	1915	13.21

BLAST FURNACES.

The number of furnaces in blast on June 30 and December 31 and the total number of stacks recorded for the years 1914 and 1915, not including the electric reduction furnace at Heroult, Cal., as published by the bureau of statistics of the American Iron and Steel Institute, are as follows:

Blast furnaces in the United States, 1914 and 1915.

State.	Furnaces in blast June 30, 1914.	Dec. 31, 1914.			Furnaces in blast June 30, 1915.	Dec. 31, 1915.		
		In.	Out.	Total.		In.	Out.	Total.
Pennsylvania	76	63	96	159	96	125	31	156
Ohio	43	31	43	74	50	62	12	74
Illinois	12	7	19	26	12	21	5	26
Alabama	20	18	30	48	20	27	20	47
New York	13	12	15	27	16	18	9	27
Virginia	8	3	19	22	5	7	15	22
Tennessee	6	4	14	18	5	6	12	18
Colorado	2	2	4	6	2	2	4	6
Missouri	1	1	1	2	1	1	1	2
Oregon	0	0	1	1	0	0	1	1
Washington	0	0	1	1	.....	.....	.....	.....
California	0	0	0	0	0	0	0	0
Maryland	2	2	3	5	2	3	2	5
New Jersey	2	1	5	6	1	1	4	5
Wisconsin	3	3	5	8	4	7	1	8
Minnesota	1	0	1	1	1	2	0	2
Indiana	8	4	6	10	10	10	0	10
Michigan	8	9	5	14	8	11	3	14
West Virginia	1	1	3	4	1	3	1	4
Kentucky	1	1	5	6	1	3	3	6
Georgia	0	0	4	4	0	0	4	4
Texas	0	0	3	3	0	0	2	2
Mississippi	0	0	1	1	0	0	1	1
Connecticut	1	1	2	3	1	1	2	3
Massachusetts	0	1	1	2	0	0	2	2
	208	164	287	451	236	310	135	445

MONTHLY PRODUCTION OF PIG IRON.

The accompanying diagram (fig. 5) illustrates the course of the manufacture of pig iron by months during the last six years. The high production at the beginning of 1910 followed by a gradual, almost uninterrupted, decline throughout that year, the moderate production during 1911, broken by alternating declines and recoveries, the rising production of 1912 and early 1913, the decline from the middle of 1913 to the close of 1914 broken by feeble rallies in March and August, 1914, and finally the rapid rise in production from month to month throughout 1915 broken only slightly in November, but culminating in the record production in December of 3,203,322 gross tons, are graphically indicated.

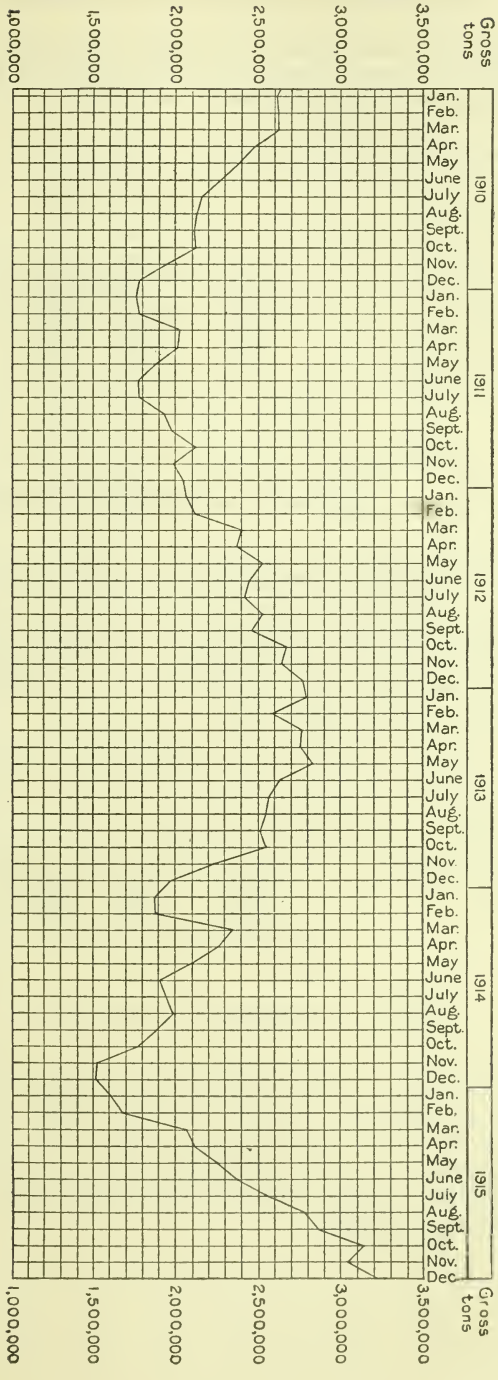

FIGURE 5.—Curve showing production of coke and anthracite pig iron in the United States, 1910 to 1915, by months.

PRODUCTION OF PIG IRON, BY GRADES.

The statistics of production of the principal grades of pig iron in 1911 were published by the American Iron and Steel Association and by the American Iron and Steel Institute for 1912 to 1915, as follows:

Pig iron manufactured in the United States, 1911–1915, by grades, in gross tons.

Grade.	1911	1912	1913	1914	1915
Bessemer and low phosphorus	9,409,303	11,664,015	11,590,113	7,859,127	10,523,306
Basic (mineral fuel)	8,520,020	11,417,886	[a]12,536,693	[a]9,670,687	[a]13,093,214
Forge pig iron	408,841	469,183	324,407	361,651	316,214
Foundry and ferrosilicon	4,468,940	5,073,873	5,220,343	4,533,254	4,864,348
Malleable	612,533	825,643	993,736	671,771	829,921
Spiegeleisen	110,236	96,346	110,338	79,935	97,885
Ferromanganese	74,482	125,378	119,495	106,083	129,072
White, mottled, direct castings, etc	45,192	54,613	71,027	49,736	62,253
	23,649,547	29,726,937	30,966,152	23,332,244	29,916,213

[a] Includes a small quantity of basic iron made with charcoal.

PRODUCTION OF PIG IRON ACCORDING TO FUEL USED.

In the following table are given the statistics of the American Iron and Steel Association showing the production of pig iron according to the fuel used in 1911 and those of the American Iron and Steel Institute since 1912. The charcoal figures include small quantities of pig iron made with charcoal and electricity. The totals for each of the five years also include small quantities of ferroalloys made with electricity, coke and electricity, etc.

Pig iron manufactured in the United States, 1911–1915, by fuel used, in gross tons.

Fuel used.	1911	1912	1913	1914	1915
Bituminous, chiefly coke	23,141,296	29,132,733	30,326,130	22,976,856	29,535,308
Anthracite and coke	212,548	236,467	277,595	89,569	84,753
Anthracite alone	17,027	10,712	22,446	1,895	.....
Charcoal	278,676	347,025	339,981	263,924	296,152
	23,649,547	29,726,937	30,966,152	23,332,244	29,916,213

TOTAL PRODUCTION OF PIG IRON.

The following table shows the production of pig iron, including the commoner ferro-alloys, in the United States as far as has been recorded. The statistics for 1912 to 1915 are those of the American Iron and Steel Institute; those for years from 1854 to 1911 were collected by the American Iron and Steel Association; those for 1810, 1840, and 1850 are census figures; those for the other years are largely estimates by early statisticians.

Pig iron manufactured in the United States, 1810–1915, in gross tons.

Year.	Quantity.	Year.	Quantity.	Year.	Quantity.
1810	53,908	1866	1,205,663	1893	7,124,502
1820	20,000	1867	1,305,023	1894	6,657,388
1828	130,000	1868	1,431,250	1895	9,446,308
1829	142,000	1869	1,711,287	1896	8,623,127
1830	165,000	1870	1,665,179	1897	9,652,680
1831	191,000	1871	1,706,793	1898	11,773,934
1832	200,000	1872	2,548,713	1899	13,620,703
1840	286,903	1873	2,560,963	1900	13,789,242
1842	215,000	1874	2,401,262	1901	15,878,354
1846	765,000	1875	2,023,733	1902	17,821,307
1847	800,000	1876	1,868,961	1903	18,009,252
1848	800,000	1877	2,066,594	1904	16,497,033
1849	650,000	1878	2,301,215	1905	22,992,380
1850	563,755	1879	2,741,853	1906	25,307,191
1852	500,000	1880	3,835,191	1907	25,781,361
1854	657,337	1881	4,144,254	1908	15,936,018
1855	700,159	1882	4,623,323	1909	25,795,471
1856	788,515	1883	4,595,510	1910	27,303,567
1857	712,640	1884	4,097,868	1911	23,649,547
1858	629,548	1885	4,044,526	1912	29,726,937
1859	750,560	1886	5,683,329	1913	30,966,152
1860	821,223	1887	6,417,148	1914	23,332,244
1861	653,164	1888	6,489,738	1915	29,916,213
1862	703,270	1889	7,603,642		
1863	846,075	1890	9,202,703		549,904,611
1864	1,014,282	1891	8,279,870		
1865	831,770	1892	9,157,000		

MARKET PRICES OF PIG IRON.

The average monthly prices of the principal grades of pig iron either at the blast furnaces or at the nearest market for 1914 and 1915, according to published market quotations, are of interest in comparison with the general average price per ton of pig iron in the United States ($13.21) reported to the Survey by blast-furnace operators. The accompanying diagram (fig. 6) graphically shows the price curve of basic pig iron at the blast furnaces in the Mahoning and Shenango valleys, Pa., 1910 to 1915, inclusive. The price reached in December, 1915, $17.50 per ton, is the highest reached in the 6-year period covered in the diagram, but in May, 1907, the price quoted was $22.90 per ton.

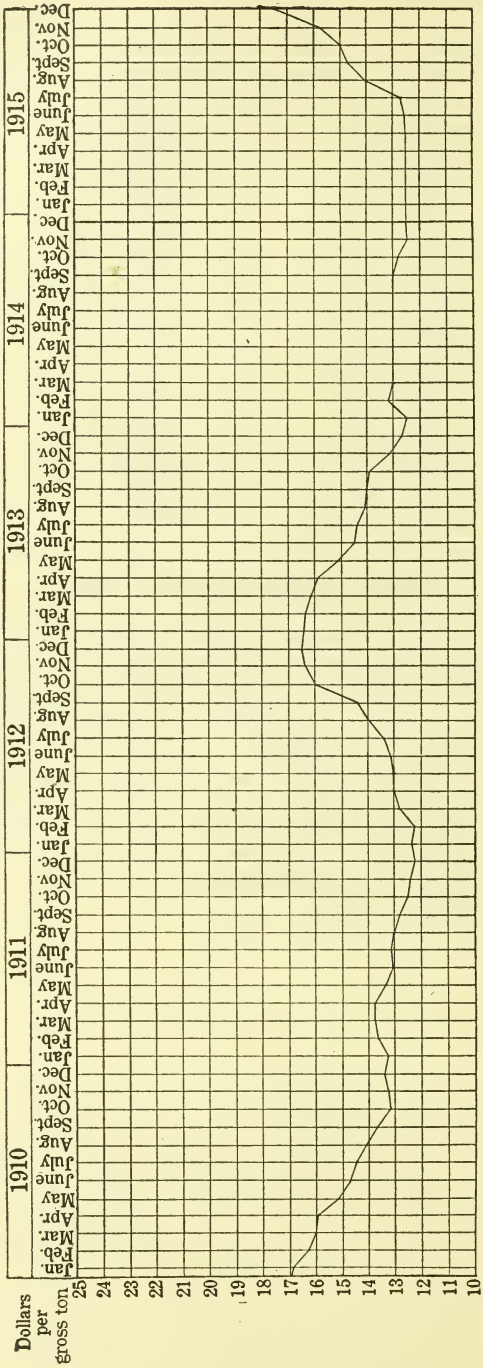

FIGURE 6.—Curve showing prices of basic pig iron at blast furnaces in Mahoning and Shenango Valleys, Pa., 1910 to 1915, by months.

Average monthly prices per ton of pig iron, 1914 and 1915.[a]

Month.	1914				1915			
	Foundry pig iron at Valley furnaces.	Foundry No. 2 pig iron at Birmingham, Ala., furnaces.	Bessemer pig iron at Valley furnaces.	Basic pig iron at Valley furnaces.	Foundry pig iron at Valley furnaces.	Foundry No. 2 pig iron at Birmingham, Ala., furnaces.	Bessemer pig iron at Valley furnaces.	Basic pig iron at Valley furnaces.
January	$13.00	$10.63	$14.06	$12.51	$12.75	$9.50	$13.75	$12.50
February	13.21	10.52	14.13	13.21	12.75	9.50	13.64	12.50
March	13.25	10.75	14.20	13.05	12.75	9.42	13.60	12.50
April	13.25	10.52	14.00	13.00	12.75	9.25	13.60	12.50
May	13.17	10.50	14.00	13.00	12.75	9.47	13.60	12.50
June	13.00	10.29	14.00	13.00	12.70	9.50	13.75	12.57
July	13.00	10.06	14.00	13.00	12.72	9.61	13.98	12.87
August	13.00	10.00	14.00	13.00	13.71	10.77	15.12	13.98
September	13.00	10.00	14.00	13.00	14.50	11.22	15.93	14.80
October	12.89	10.00	13.97	12.88	14.58	11.71	16.00	15.00
November	12.75	10.00	13.75	12.50	15.82	13.14	16.67	15.88
December	12.75	9.67	13.75	12.50	17.98	14.00	19.19	17.73
Average	13.02	10.25	13.99	12.89	13.81	10.59	14.90	13.78

[a] Metal statistics, New York, 1916.

The following table, compiled by the Iron Trade Review, summarizes the selling prices at Valley furnaces of Bessemer and Foundry No. 2 pig iron at the beginning of the buying season for the last 27 years:

Selling price of pig iron, 1890–1916, at date of buying movement.

Season.	Date of buying movement.	Iron prices; Valley.		Season.	Date of buying movement.	Iron prices; Valley.	
		Bessemer.	Foundry iron No. 2.			Bessemer.	Foundry iron No. 2.
1890	Dec. 15, 1889	$22.15	$18.15	1904	Apr. 15, 1904	$13.35	$13.15
1891	June 1, 1891	15.15	15.00	1905	Feb. 1, 1905	15.50	16.00
1892	Jan. 31, 1892	15.00	13.65	1906	Dec. 5, 1905	17.25	17.25
1893	Mar. 15, 1893	12.65	12.15	1907	Nov. 5, 1906	21.50	21.50
1894	Mar. 1, 1894	9.65	9.60	1908	June 15, 1908	16.00	15.00
1895	Apr. 1, 1895	9.40	9.45	1909	May 10, 1909	14.75	14.25
1896	May 1, 1896	12.40	11.15	1910	Dec. 24, 1909	19.00	17.25
1897	May 20, 1897	8.35	8.40	1911	Apr. 21, 1911	15.00	13.75
1898	Mar. 20, 1898	9.55	9.80	1912	Mar. 20, 1912	14.25	13.25
1899	Feb. 1, 1899	10.30	9.75	1913	Nov. 19, 1912	17.25	17.50
1900	Dec. 15, 1899	24.15	22.15	1914	May 1, 1914	14.00	13.25
1901	Apr. 15, 1901	16.15	14.40	1915	Apr. 19, 1915	13.60	12.75
1902	Feb. 1, 1902	15.90	15.90	1916	Dec. 7, 1915	18.50	18.00
1903	Mar. 20, 1903	21.50	21.65				

FOREIGN TRADE IN PIG IRON.

IMPORTS.

The quantity of pig iron and ferroalloys, the principal of which were ferromanganese, spiegeleisen, and ferrosilicon, imported into the United States in 1915, was 89,836 gross tons, compared with 138,903 tons imported in 1914, a decrease of 49,067 tons, or 35 per cent. The United Kingdom furnished the largest quantity in both years; Canada, China, and British India followed in order of importance in 1915.

The statistics of imports of iron are compiled from the records of the Bureau of Foreign and Domestic Commerce, Department of Commerce, and the following table gives the imports from the various countries from 1911 to 1915:

Pig iron, including kentledge, ferromanganese, ferrosilicon, and spiegeleisen, imported into the United States, 1911–1915, in gross tons.

Country.	1911	1912	1913	1914	1915
Austria-Hungary	590	400	340	899	.....
Germany	4,286	5,924	8,358	10,609	600
Netherlands	9,719	492	460	2,539	.....
United Kingdom {England	114,947	110,526	131,340	90,627	59,105
United Kingdom {Scotland			1,581	1,012	792
Canada	4,260	4,998	4,609	25,968	21,166
China	11,857	1,750	3,017	200	3,430
Belgium	.....	.....	256	500	.....
France	.....	.....	179	40	20
Norway	.....	.....	117	225	.....
Sweden	.....	.....	2,002	2,329	1,392
Switzerland	.....	.....	1,680	.....	.....
Cuba	.....	.....	72	.....	.....
British India	.....	.....	2,439	1,310	2,382
China, leased territory (British)	.....	.....	.....	1,285	.....
Italy	.....	.....	.....	550	.....
Australia and Tasmania	.....	.....	.....	90	.....
Newfoundland and Labrador	.....	.....	.....	200	.....
Hongkong	.....	.....	.....	200	.....
Peru	.....	.....	.....	250	.....
Japan	.....	.....	.....	70	250
Other countries	2,800	5,235	.....	.....	699
	148,459	129,325	156,450	138,903	89,836

EXPORTS.

The quantity of pig iron exported from the United States in 1915 was 224,509 gross tons, compared with 114,423 tons in 1914, an increase of 110,086 tons, or 96 per cent. The largest quantity was shipped to Italy, and important quantities were shipped also to Canada, England, France, Chile, Panama, and Australia and Tasmania. The iron trade with South American countries is very small.

The following table shows the exports of pig iron from the United States to the various foreign countries by calendar years from 1911 to 1915, according to records of the Bureau of Foreign and Domestic Commerce:

Pig iron exported from the United States to foreign countries, 1911–1915, in gross tons.

Country.	1911	1912	1913	1914	1915
Canada	98,293	208,581	193,396	57,852	60,197
Austria-Hungary	.....	14,806	4,601	1,150	.....
Italy	7,710	11,954	24,551	14,288	81,792
United Kingdom: England	8,526	25,617	20,972	18,013	57,368
United Kingdom: Scotland			396	148	.....
United Kingdom: Ireland			26	.....	.....
Germany	293	2,403	1,723	749	.....
Belgium	622	1,698	4,715	1,219	.....
France	202	827	752	397	9,414
Denmark	125	168	48	.....	.....
Mexico	444	804	85	454	684
Panama	1,079	1,606	3,921	1,056	2,316
Cuba	1,122	734	646	593	844
Brazil	.....	50	1,305	575	304
Chile	600	1,964	690	1,875	2,716
Peru	875	835	172	200	286
Philippines	.....	259	54	57	54
Netherlands	.....	.....	1,516	1,467	1,993
Portugal	.....	.....	25	50	.....
Costa Rica	.....	.....	310	18	50
Honduras	.....	.....	5	8	.....
San Domingo	.....	.....	40	.....	4
Argentina	.....	.....	792	1,042	912
Colombia	.....	.....	13	10	29
Uruguay	.....	.....	112	100	.....
Venezuela	.....	.....	50	65	32
Japan	.....	.....	2,293	2,938	1,811
Australia and Tasmania	.....	.....	14,354	10,099	2,008
New Zealand	.....	.....	85	.....	.....
Other countries	908	370	.....	.....	1,695
	120,799	272,676	277,648	114,423	224,509

PRODUCTION OF PIG IRON IN PRINCIPAL COUNTRIES.

The following table is taken from "Metal Statistics." The grand totals are regarded as representing the world's production of pig iron, and the fact that the United States produces about 40 per cent of the total and yet exports relatively so little is of interest.

Pig iron manufactured in principal countries in 1850, 1890, 1900, 1910, 1913, and 1914, in gross tons.[a]

Country.	1850	1890	1900	1910	1913	1914
United States	563,755	9,202,703	13,789,242	27,303,567	30,966,152	23,332,244
Germany	350,000	4,584,882	8,381,373	14,559,509	[b]19,004,022	[b]14,162,147
Great Britain	2,300,000	7,904,214	8,959,691	10,012,098	10,481,917	9,005,898
France	405,653	1,931,188	2,669,966	3,974,478	5,227,378	[c]3,500,000
Russia	227,555	912,561	2,889,789	2,992,058	4,474,757	4,190,000
Austria-Hungary	250,000	910,685	1,472,695	2,153,788	2,335,170	[c]1,500,000
Belgium	144,452	775,385	1,001,872	1,822,821	2,318,767	[c]1,500,000
Canada	.....	19,439	86,090	740,210	1,015,118	705,972
Sweden	150,000	483,155	518,263	594,385	730,659	629,608
Spain	.....	176,598	289,315	367,423	418,061	[c]400,000
Italy	.....	14,094	23,569	347,657	420,011	379,028
Other countries	10,000	80,000	100,000	400,000	500,000	500,000
	4,401,415	26,994,904	40,181,865	65,267,994	77,892,012	59,804,897

[a] Metal Statistics, 1916, p. 41, The American Metal Market Co., New York.
[b] Provisional.
[c] Estimated.

NOTE.—The estimate for 1915 is 60,000,000 gross tons.

FERROALLOYS.[1]

SHIPMENTS AND VALUE.

The quantity of ferroalloys reported is small, amounting to only about 1.28 per cent of the total marketed production of pig iron during 1915, but the value per ton is so much greater as to have an important influence on the apparent average value of the pig iron, if included with it, making it $13.61 a ton instead of $13.21.

There is generally a sufficient number of producers of the commoner ferroalloys, such as ferromanganese, spiegeleisen, and ferrosilicon, to enable the Survey to give the production of these three types of alloys separately; but the production of the rarer alloys, such as ferromolybdenum, ferrotitanium, ferrotungsten, and ferrovanadium, must be grouped together, and as there are less than three reporting producers of ferrophosphorus the production of this alloy is grouped with that of ferrosilicon. It should be stated that the values of the first two groups of ferroalloys shown in the next table were almost wholly estimated by the Survey for 1913, but not for 1914 and 1915, and the values of the rarer alloys have been estimated in part for all the years given except for 1915.

The shipments of ferroalloys in 1915, as reported to the United States Geological Survey, were 388,644 gross tons, valued at $17,450,385, as compared with 255,524 gross tons, valued at $9,350,245, in 1914. Of the shipments in 1915, 147,822 gross tons, valued at $11,452,577, were made from imported ores derived from Australia, Cuba, India, Japan, Russia, South America, and Spain. The ferrovanadium, ferromolybdenum, ferromanganese, spiegeleisen, and ferrotungsten were made in part or wholly from imported ore. The quantity reported falls far short of the real production of the United States, as data concerning the sales of considerable quantities of electrically produced ferroalloys could not be obtained by the Survey.

The sales of ferromanganese and spiegeleisen in 1915 amounted to 258,816 gross tons, valued at $11,656,993, compared with 177,356 tons, valued at $6,026,392, sold in 1914. The figures for ferromanganese and spiegeleisen, which may be shown separately for 1914 and 1915, are as follows: 1915, ferromanganese, 144,260 gross tons, valued at $9,253,443; spiegeleisen, 114,556 gross tons, valued at $2,403,550; 1914, ferromanganese, 100,731 gross tons, valued at $4,440,253; spiegeleisen, 76,625 gross tons, valued at $1,586,139. The sales of ferrosilicon and ferrophosphorus in 1915 amounted to 128,263 gross tons, valued at $2,595,265, compared with 77,182 gross tons, valued at $1,621,830, in 1914. The sales of alloys of iron, with the rarer metals molybdenum, titanium,[2] tungsten, and vanadium, as reported to the Survey, amounted in 1915 to 1,565 gross tons, valued at $3,198,127, compared with 986 gross tons, valued at $1,702,023, in 1914, an increase in quantity of 579 tons, and in value of $1,496,104. These alloys were therefore valued at an average price of $2,044 a ton in 1915, compared with an average price of more than $1,726 a ton in 1914.

[1] Notes on manganese ferroalloys are given also in the chapter on the production of manganese and manganiferous ores in Mineral Resources for 1915, pp. 36–38.

[2] No ferrotitanium reported in 1914 or 1915.

The following table gives a very incomplete outline of the ferroalloys sales in the United States in 1913, 1914, and 1915:

Ferroalloys of domestic manufacture sold in 1913, 1914, and 1915.

Variety of alloy.	1913		1914		1915	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Ferromanganese	226,475	$9,272,269	100,731	$4,440,253	144,260	$9,253,443
Spiegeleisen			76,625	1,586,139	114,556	2,403,550
Ferrosilicon	67,164	1,233,465	77,182	1,621,830	128,263	2,595,265
Ferrophosphorus						
Ferromolybdenum						
Ferrotitanium [a] (10 to 20 per cent titanium)	2,568	2,509,628	986	1,702,023	1,565	3,198,127
Ferrovanadium						
Ferrotungsten (50 per cent or above tungsten)						
	296,207	13,015,362	255,524	9,350,245	388,644	17,450,385

[a] No ferrotitanium reported in 1914 or 1915.

IMPORTS.

According to the reports of the Bureau of Foreign and Domestic Commerce, the imports of ferromanganese into the United States in 1915 for consumption were 55,263 gross tons, valued at $3,333,699, or $60.32 per ton, as compared with 82,997 gross tons, valued at $3,619,607, or $43.61 per ton, in 1914, and those of spiegeleisen in 1915 were 200 gross tons, valued at $5,110, or $25.55 per ton, as compared with 2,870 gross tons, valued at $71,147, or $24.79 per ton, in 1914. The imports of the alloys of the rarer metals are not all reported separately. For instance, the imports of ferrochrome are combined with those of chromium, those of ferromolybdenum are combined with those of the metal molybdenum, and those of ferrotungsten are included with those of tungsten. For the sake of comparison, however, such statistics as are available are presented in the following table:

Ferroalloys imported for consumption in the United States in 1913, 1914, and 1915.

Variety of alloy.	1913		1914		1915	
	Quantity (gross tons).	Value.	Quantity. (gross tons).	Value.	Quantity (gross tons).	Value.
Chrome or chromium and ferrochrome	307	$51,415	200	$21,553	32	$1,662
Ferrophosphorus			26	1,136	12	617
Ferrosilicon	7,208	449,871	6,249	341,925	5,128	311,219
Molybdenum and ferromolybdenum	7	15,939	.10	59		203
Titanium and ferrotitanium	15	7,198	18	8,356		
Tungsten and ferrotungsten	661	835,212	195	222,447	7	9,588
Ferromanganese	128,070	5,682,915	82,997	3,619,607	55,263	3,333,699
Spiegeleisen	77	2,173	2,870	71,147	200	5,110
	136,345	7,044,723	92,555.10	4,286,230	60,642	3,662,098

PRODUCTION OF STEEL, BY STATES AND KINDS.

The subjoined tables showing the production of steel were compiled by the American Iron and Steel Association prior to 1912 and by the bureau of statistics of the American Iron and Steel Institute since 1912. Unfortunately no data whatever are available on the value of the steel output.

Bessemer steel ingots and castings manufactured in the United States, 1911–1915, in gross tons.

State.	1911	1912	1913	1914	1915
Ohio	3,268,994	4,285,673	4,024,662	2,862,700	3,929,665
Pennsylvania	2,338,813	3,157,928	2,954,818	2,014,526	2,507,243
Illinois	1,335,053	1,559,576	1,475,274	871,110	1,270,502
Other States	1,004,994	1,324,724	1,090,952	472,510	579,803
	7,947,854	10,327,901	9,545,706	6,220,846	8,287,213

Open-hearth steel ingots and castings manufactured in the United States, 1911–1915, in gross tons.

State.	1911	1912	1913	1914	1915
New England States	189,879	214,325	195,419	137,962	191,582
New York and New Jersey	679,152	792,201	996,312	719,227	1,266,017
Pennsylvania	9,594,914	12,408,109	12,522,227	9,854,038	13,245,393
Ohio	1,721,549	2,565,343	2,726,219	2,592,778	3,521,404
Indiana	1,394,520	2,001,937	2,180,106	1,628,840	2,504,427
Illinois	801,624	1,235,166	1,264,854	896,610	1,169,657
Other States	1,217,012	1,563,642	1,714,794	1,345,229	1,780,622
	15,598,650	20,780,723	21,599,931	17,174,684	23,679,102

PRODUCTION OF ELECTRIC STEEL.[1]

The production of steel by the electric process in 1915 amounted to 69,412 gross tons, as compared with 24,009 tons in 1914, an increase of 45,403 tons, or more than 189 per cent. The following table gives the production of electric steel ingots and castings since 1909. In 1908 there were 55 tons of electric steel produced, but this quantity was included with open-hearth steel for that year.

In the total production of electric steel in 1915 are included 27,944 tons of steel ingots and castings which were treated with ferrovanadium, ferrotitanium, ferrochrome, and other alloys, of which 27,848 tons were ingots and 96 tons were castings. In 1914 the production of similarly treated steel amounted to about 9,344 tons, 9,004 tons of ingots, and 340 tons of castings.

On December 31, 1915, the number of completed plants which were equipped for the manufacture of steel by the electric process was 34, as compared with 20 plants at the close of 1914, a gain of 14 plants.

Steel electrically manufactured in the United States, 1909 to 1915, in gross tons.

Year.	Ingots.	Castings.	Total.
1909	13,456	306	13,762
1910	50,821	1,320	52,141
1911	27,227	1,878	29,105
1912	14,147	4,162	18,309
1913	20,973	9,207	30,180
1914	15,458	8,551	24,009
1915	46,348	23,064	69,412

[1] Bureau of statistics of American Iron and Steel Institute.

TOTAL DOMESTIC PRODUCTION OF STEEL.

Steel produced in the United States, 1810–1915, in gross tons.

Year.	Bessemer.	Open-hearth.	Crucible.	Other steel.	Total.
1810	.....	.....	917		917
1860	.....	.....	11,838		11,838
1863	.....	.....	8,075		8,075
1864	.....	.....	9,258		9,258
1865	.....	.....	13,627		13,627
1866	.....	.....	16,940		16,940
1867	2,679	.....	16,964		19,643
1868	7,589	.....	19,197		26,786
1869	10,714	893	19,643		31,250
1870	37,500	1,339	29,911		68,750
1871	40,179	1,785	31,250		73,214
1872	107,239	2,679	26,125	6,911	142,954
1873	152,368	3,125	31,059	12,244	198,796
1874	171,369	6,250	32,436	5,672	215,727
1875	335,283	8,080	35,180	11,256	389,799
1876	469,639	19,187	35,163	9,202	533,191
1877	500,524	22,349	36,098	10,647	569,618
1878	653,773	32,255	38,309	7,640	731,977
1879	829,439	50,259	50,696	4,879	935,273
1880	1,074,262	100,851	64,664	7,558	1,247,335
1881	1,374,247	131,202	80,145	2,720	1,588,314
1882	1,514,687	143,341	75,973	2,691	1,736,692
1883	1,477,345	119,356	71,835	4,999	1,673,535
1884	1,375,531	117,515	53,270	4,563	1,550,879
1885	1,519,430	133,376	57,599	1,515	1,711,920
1886	2,269,190	218,973	71,973	2,367	2,562,503
1887	2,936,033	322,069	75,375	5,594	3,339,071
1888	2,511,161	314,318	70,279	3,682	2,899,440
1889	2,930,204	374,543	75,865	5,120	3,385,732
1890	3,688,871	513,232	71,175	3,793	4,277,071
1891	3,247,417	579,753	72,586	4,484	3,904,240
1892	4,168,435	669,889	84,709	4,548	4,927,581
1893	3,215,686	737,890	63,613	2,806	4,019,995
1894	3,571,313	784,936	51,702	4,081	4,412,032
1895	4,909,128	1,137,182	67,666	858	6,114,834
1896	3,919,906	1,298,700	60,689	2,394	5,281,689
1897	5,475,315	1,608,671	69,959	3,012	7,156,957
1898	6,609,017	2,230,292	89,747	3,801	8,932,857
1899	7,586,354	2,947,316	101,213	4,974	10,639,857
1900	6,684,770	3,398,135	100,562	4,862	10,188,329
1901	8,713,302	4,656,309	98,513	5,471	13,473,595
1902	9,138,363	5,687,729	112,772	8,386	14,947,250
1903	8,592,829	5,829,911	102,434	9,804	14,534,978
1904	7,859,140	5,908,166	83,391	9,190	13,859,887
1905	10,941,375	8,971,376	102,233	8,963	20,023,947
1906	12,275,830	10,980,413	127,513	14,380	23,398,136
1907	11,667,549	11,549,736	131,234	14,075	23,362,594
1908	6,116,755	7,836,729	63,631	6,132	14,023,247
1909	9,330,783	14,493,936	107,355	22,947	23,955,021
1910	9,412,772	16,504,509	122,303	55,335	26,094,919
1911	7,947,854	15,598,650	97,653	31,949	23,676,106
1912	10,327,901	20,780,723	121,517	21,162	31,251,303
1913	9,545,706	21,599,931	121,226	34,011	31,300,874
1914	6,220,846	17,174,684	89,869	27,631	23,513,030
1915	8,287,213	23,679,102	113,782	70,939	32,151,036

FOREIGN TRADE IN STEEL.

The extraordinary development of the export trade in steel in the United States during 1915 seems to justify the insertion of a table showing by classes the exports of manufactured iron and steel from this country in 1914 and 1915. For comparison the imports are tabulated also. The figures were compiled from records of the Bureau of Foreign and Domestic Commerce.

Iron and steel imported into the United States, 1914 and 1915.

Article.	1914		1915	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Scrap iron and steel	34,839	$277,818	79,982	$761,719
Bar iron	15,015	625,365	8,474	417,491
Ingots, blooms, slabs, etc., not elsewhere specified	2,099	57,682	4,412	187,623
Ingots, blooms, and slabs, billets and bars of steel, and steel in forms, not elsewhere specified	38,090	2,885,365	10,586	1,753,978
Hoop or band iron or steel for baling	[a] 648	23,702	.....	28
Rails for railway	22,571	610,037	78,525	2,088,532
Sheets and plates	4,310	514,080	1,420	218,954
Tin and terne plates	15,411	1,049,297	2,350	196,328
Wire rods	6,954	373,615	5,317	331,724
	139,937	6,416,961	191,066	5,956,377
Wire and articles made from wire	.....	1,205,456	.....	640,521
All other manufactures	.....	3,674,401	.....	2,234,447
	.....	4,879,857	.....	2,874,968
Grand total	.....	11,296,818	.....	8,851,345

[a] Beginning July 1, 1914.

Iron and steel exported from the United States, 1914 and 1915.

Article.	1914		1915	
	Quantity (gross tons).	Value.	Quantity (gross tons).	Value.
Scrap and old, fit only for manufacture	33,134	$386,208	79,361	$1,111,254
Bar iron	5,226	203,835	39,740	1,471,466
Bars or rods (of steel), wire rods	61,856	1,810,389	165,015	4,713,109
All other	123,008	4,612,197	425,678	16,412,440
Billets, ingots, and blooms, not elsewhere specified	50,496	1,103,702	560,704	14,176,528
Bolts and nuts	15,127	1,234,440	23,536	1,896,842
Hoop and bands	9,954	457,451	29,249	1,433,879
Horseshoes	5,903	748,136	15,863	2,741,724
Cut nails	3,423	142,285	4,236	190,667
Railroad spikes	6,915	258,808	13,256	591,752
Wire nails	36,124	1,603,904	91,584	4,371,072
All other (including tacks)	3,183	401,319	9,251	1,085,416
Cast-iron pipes and fittings	38,418	1,462,670	47,022	2,128,025
Wrought-iron pipes and fittings	56,717	3,355,120	129,966	8,081,416
Radiators and cast-iron house-heating boilers	3,572	278,775	2,291	183,523
Rails for railways, of steel	174,680	5,103,918	391,379	12,095,170
Galvanized iron and steel plates	40,463	2,723,971	75,905	5,381,303
Iron sheets and plates, all other	7,555	404,213	25,543	1,221,699
Steel plates	111,642	4,198,106	223,806	8,037,551
Steel sheets	120,436	5,110,206	94,349	3,726,933
Structural iron and steel	182,395	6,961,636	232,139	8,960,411
Tin and terne plates	59,549	4,337,779	154,641	11,501,995
Barbed wire	93,846	4,633,348	248,611	13,933,234
All other wire	87,022	3,935,241	224,972	11,900,373
	1,330,644	55,467,657	3,308,097	137,347,782
Axes	.....	751,313	.....	588,443
Hammers and hatchets	.....	265,682	.....	509,824
Railway-track material (except rails and spikes, switches, frogs, fishplates, splices, bars, etc.)	.....	1,775,391	.....	4,857,047
Saws	.....	1,158,122	.....	1,294,447
Shovels and spades	.....	263,733	.....	352,727
All other tools	.....	6,306,382	.....	8,676,483
	.....	10,520,623	.....	16,278,971
Grand total	.....	65,988,280	.....	153,626,753

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GOLD, SILVER, AND LEAD IN SOUTH DAKOTA.

(MINES REPORT.)

By Charles W. Henderson.

PRODUCTION.

The total value of the production of gold, silver, and lead in South Dakota in 1915, as reported from 33 productive mines, 10 of which were placers, amounted to $7,507,782, an increase of $76,439 over the yield of 1914. The output of gold in 1915 was 358,280 fine ounces, valued at $7,406,305, nearly 99 per cent of the total value. The increase in the yield of gold for the year was 3,521.55 fine ounces in quantity and $72,797 in value. The production of silver also increased from 176,642 to 199,864 fine ounces. Smelting ore from South Dakota carried no copper and only 3,107 pounds of lead. The output of placer gold amounted to only 76.72 ounces. Some of the placer gold was sold for use in the arts.

The total quantity of ore mined and treated in 1915 was 1,889,975 short tons, averaging in recovered gold 0.1895 ounce, or $3.92 in gold per ton, as compared with 2,019,262 short tons, averaging $3.63, in 1914; 1,899,167 short tons, averaging $3.85, in 1913; 1,901,726 short tons, averaging $4.14, in 1912; 1,946,127 short tons, averaging $3.187, in 1911; and 1,523,929 short tons, averaging $3.543, in 1910. There were 1,888,598 tons treated in the mills of the State, yielding as bullion $7,363,666 in gold and 196,360 fine ounces of silver, valued at $99,555, an average recovery per ton of $3.90 in gold and $0.05 in silver, as compared with $3.605 in gold and $0.05 in silver in 1914, $3.81 in gold and $0.05 in silver in 1913, $4.08 in gold and $0.06 in silver in 1912, and $3.77 in gold and $0.05 in silver in 1911. The quantity of crude ore shipped to smelters amounted to 1,377 tons, having an average content in gold of 1.442 fine ounces, or $29.81 per ton, and of 2.54 ounces in silver.

Ore sent to gold and silver mills, with quantity of gold and silver contained in bullion produced in South Dakota in 1915.

Ore to gold and silver mills.		Process.	Gold in bullion.	Silver in bullion.
			Fine oz.	*Fine oz.*
1,573,822	short tons	Amalgamation	228,315.55	63,554
1,869,248[a]	do	Cyanidation	127,901.81	132,806
			356,217.36	196,360

[a] Includes 1,554,472 tons of tailings from part of ore amalgamated.

The consumption of quicksilver and cyanide in South Dakota mills in 1915 was 13,900 pounds of quicksilver,[1] 11,477 pounds of potassium cyanide,[2] and 458,300 pounds of sodium cyanide.[2]

Mine production of gold, silver, and lead in South Dakota in 1914 and 1915.

Year.	Number of mines producing.	Ore.	Gold.[a]		Silver.[a]		Lead.		Total value.
			Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
		Short tons.	*Fine ozs.*		*Fine ozs.*		*Pounds.*		
1914	30	2,019,262	354,758.45	$7,333,508	176,642	$97,683	3,897	$152	$7,431,343
1915	33	1,889,975	358,280.00	7,406,305	199,864	101,331	3,107	146	7,507,782
Increase or decrease	+3	−129,287	+3,521.55	+72,797	+23,222	+3,648	−790	−6	+76,439

[a] Includes placer production.

Mine production of gold and silver in South Dakota, 1876–1915.[a]

Period.	Gold.	Silver.		Total value (commercial).
		Quantity.	Commercial value.	
		Fine ozs.		
1876–1880	$11,255,843	80,292	$92,452	$11,348,295
1881–1890	30,800,000	1,472,580	1,515,224	32,315,224
1891–1900	48,005,555	1,729,873	1,155,691	49,161,246
1901–1910	65,242,196	1,790,365	1,013,349	66,255,545
1911	7,439,874	203,755	107,990	7,547,864
1912	7,891,370	206,460	126,973	8,018,343
1913	7,319,294	172,702	104,312	7,423,606
1914	7,333,508	176,642	97,683	7,431,191
1915	7,406,305	199,864	101,331	7,507,636
Total	192,693,945	6,032,533	4,315,005	197,008,950

[a] For yearly output and authority for each, see U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 42, 1914.

Gold and silver produced in South Dakota in 1915, by sources.

Source.	Number of mines.	Ore.	Gold.		Silver.		Total value.
			Quantity.	Value.	Quantity.	Value.	
		Short tons.	*Fine ozs.*		*Fine ozs.*		
Deep mines:							
Siliceous ore	22	1,889,970	358,203.14	$7,404,716	199,795	$101,296	$7,506,012
Lead ore	1	5	.14	3	63	32	35
	23	1,889,975	358,203.28	7,404,719	199,858	101,328	7,506,047
Placer mines	10	.....	76.72	1,586	6	3	1,589
	33	1,889,975	358,280.00	7,406,305	199,864	101,331	7,507,636

[1] Represents 1 pound of mercury per 16.43 ounces of gold, or 1 pound of mercury per 113 tons of ore.

[2] Potassium and sodium cyanide were used at a ratio of 0.25 pound of cyanide per ton of ore or tailings treated, and for every pound used there was recovered 0.272 ounce of gold.

MINING INDUSTRY IN 1915.

GENERAL CONDITIONS.

The Homestake mines and mills were operated continuously in 1915. This company completely rebuilt its Pocahontas mill and one-half of the Amicus mill. The Golden Reward mill was operated steadily on siliceous ore from its mines and on custom ore; in addition, a considerable quantity of partly oxidized ore was roasted at the Astoria shaft and sent to the mill. The Mogul cyanidation mill was operated steadily on company and custom ore, with increased capacity. The Reliance and the Trojan mills were operated steadily. The Wasp No. 2 Co. continued to operate its dry-crushing cyanidation mill. The Bismarck mine and mill were idle. The new 50-ton cyanidation mill on the Rattlesnake Jack mine was operated for a period. A small yield of placer gold was made in Custer, Lawrence, and Pennington counties.

REDUCTION MILLS.

Mineral Resources for 1913, Part I, pages 43–45, contains a complete list of the reduction mills in South Dakota in 1913, with description of equipment and process. Changes in this list for 1915 have been noted in the text of the various counties, and reference should be made to the 1913 report for details of equipment.

REVIEW BY COUNTIES.

CUSTER COUNTY.

Mine production of gold, silver, copper, and lead in Custer County, S. Dak., 1904–1915.

Year.	Number of mines producing.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	4	1,900	$6,491	121	.....	.....	$6,560
1905	5	16	706	3	38	.....	714
1906	2	16	687	3	.....	.....	689
1907	1	33	332	3	.....	.....	334
1908	2	470	1,533	4	.....	.....	1,535
1909	1	400	1,311	21	.....	.....	1,322
1910	.....	.....	.....	.....	.....	.....	.....
1911	5	.....	309	4	.....	.....	311
1912	5	75	1,187	3	.....	.....	1,189
1913	5	5	194	1	1,503	.....	428
1914	2	17	206	5	.....	.....	209
1915	3	5	409	65	.....	3,107	588
Increase or decrease	+1	−12	+203	+60	.....	+3,107	+379

[a] Includes both placer and deep mines.

A small shipment of silver-lead ore was made from Hermosa. A small yield of placer gold was recovered by sluicing and rocker near Custer.

LAWRENCE COUNTY.[1]

Mine production of gold, silver, copper, and lead in Lawrence County, S. Dak., 1904–1915.

Year.	Number of mines producing.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces*	*Pounds.*	*Pounds.*	
1904	44	1,801,524	$7,346,986	161,216	.....	.....	$7,439,282
1905	19	1,826,177	6,955,690	182,597	.....	.....	7,065,979
1906	27	1,771,377	6,816,196	150,537	.....	22,719	6,918,351
1907	22	1,470,154	4,134,667	93,830	.....	.....	4,196,595
1908	17	1,927,844	7,650,523	248,686	.....	23,046	7,783,295
1909	17	1,699,260	6,561,628	191,044	3,977	1,512	6,661,553
1910	19	1,522,986	5,380,795	118,716	.....	14,136	5,445,523
1911	16	1,940,719	7,408,356	203,350	.....	64,311	7,519,025
1912	19	1,901,310	7,875,401	206,356	.....	22,845	8,003,338
1913	20	1,899,162	7,317,320	172,688	290	10,205	7,422,117
1914	21	2,019,016	7,331,638	176,585	.....	2,766	7,429,397
1915	25	1,889,970	7,405,552	199,797	.....	.....	7,506,849
Increase or decrease.	+4	−129,046	+73,914	+23,212	.....	−2,766	+77,452

[a] Includes both placer and deep mines.

Richard Blackstone,[2] superintendent of the Homestake Mining Co., has recently written a history of the Homestake mine, covering the present belt of consolidated properties, the Homestake, the Highland, the Golden Terra, the Deadwood, and the Father De Smet mines. These locations join each other and extend northwesterly in the order named. The Homestake mine and the Highland mine were separately incorporated and organized but were operated by the same superintendent; the Golden Terra, Deadwood, and Father De Smet each had its own superintendent and manager. Blackstone gives the total production and dividends paid by the companies now consolidated in the Homestake Mining Co. from 1875 to 1915 as follows:

Production of Homestake mine, 1875–1915.

	Ore milled.	Value of product.	Value per ton.	Dividends.
	Short tons.			
Homestake Mining Co., to May 31, 1900	.....	$31,204,685.28	.....	$8,668,750.00
Highland Mining Co., to May 31, 1900	.....	13,359,398.95	.....	3,834,717.69
Caledonia Gold Mining Co., to May 31, 1900	.....	2,341,130.92	.....	192,000.00
Deadwood-Terra Mining Co., to May 31, 1900	.....	9,001,002.61	.....	1,350,000.00
Deadwood Mining Co., to May 31, 1900	.....	834,192.28	.....	275,000.00
Father de Smet Mining Co., to May 31, 1900	.....	3,421,199.01	.....	1,125,000.00
Gopher Mining Co., to May 31, 1900	.....	71,140.41	.....	.....
Clara Consolidated Mining Co., to May 31, 1900	.....	13,590.56	.....	.....
Total to June 1, 1900	.....	60,246,340.02	.....	15,445,467.69
HOMESTAKE MINING CO.				
June 1, 1900, to June 1, 1901	.....	3,639,232.03	.....	1,260,000.00
June 1, 1901, to June 1, 1902	.....	4,303,977.57	.....	1,260,000.00
June 1, 1902, to June 1, 1903	.....	4,526,942.04	.....	819,000.00
June 1, 1903, to June 1, 1904	.....	4,800,558.48	.....	655,200.00
June 1, 1904, to June 1, 1905	.....	5,221,089.30	.....	819,000.00
June 1, 1905, to June 1, 1906	.....	5,100,445.49	.....	1,310,400.00

[1] For information on the geology of this county see Irving, J. D., Ore deposits of the northern Black Hills: U. S. Geol. Survey Bull. 225, pp. 123–140, 1904. Irving, J. D., and Emmons, S. F., Economic resources of northern Black Hills: U. S. Geol. Survey Prof. Paper 26, pp. 53–212, 1904.

[2] Blackstone, Richard, A history of the Homestake mine, South Dakota: Min. and Eng. World, July 15, 1916, pp. 99–102; South Dakota School of Mines Pahasapa Quart., June, 1916, pp. 16–30.

Production of Homestake mine, 1875–1915—Continued.

	Ore milled.	Value of product.	Value per ton.	Dividends.
	Short tons.			
June 1, 1906, to June 1, 1907	.....	$4,541,096.07	.....	$1,201,200.00
June 1, 1907, to June 1, 1908	.....	4,717,746.20	.....	546,000.00
June 1, 1908, to June 1, 1909	.....	5,725,046.67	.....	1,365,000.00
June 1, 1909, to June 1, 1910	1,237,381	4,498,751.11	$3.6357	982,800.00
June 1, 1910, to June 1, 1911	1,468,263	5,251,453.75	3.5766	1,310,400.00
June 1, 1911, to Dec. 31, 1911	888,057	3,661,151.60	4.1205	764,400.00
Calendar year 1912	1,528,923	6,600,953.12	4.3174	1,310,400.00
Calendar year 1913	1,540,961	6,186,651.78	4.0148	2,146,224.60
Calendar year 1914	1,587,774	6,160,160.59	3.8798	2,210,208.00
Calendar year 1915	1,573,822	6,428,786.56	4.0848	2,210,208.00
Grand total	.....	141,610,382.38	.....	35,615,908.29

For the calendar year 1915 the Homestake Co.'s public report says:

Operations at the mine and mills of the company for the calendar year 1915 have been continuous. The erection of the new equipment, mentioned in last annual report, has been about completed and it will soon be in operation. The Pocahontas mill has been completely rebuilt during the year. One-half of the Amicus mill has been rebuilt and rapid progress is being made toward its completion. These repairs were made with no material stoppage of milling capacity. The Columbia ditch has been rebuilt with permanent vitrified pipe. The development in the mine has been carried on without interruption, having in view the outlining of areas of new ore bodies and determination of values of same. During the year there was excavated 1,001 feet of raises and 17,114 feet of drifting. Preparations have been completed for sinking the Ellison shaft to the 2,000-foot level.

The mine and the reduction plants are in first-class condition. The measured ore reserves are large and sufficient to supply the reduction plants for many years.

In addition, this company shipped wolframite ore for which it received $21,231.51, with a net value, after mining, freight, and insurance had been deducted, of $19,237.43. An interesting disbursement of this company is the sum of $10,785.64 expended for silver-plating the amalgamation plates in some of its stamp mills.

Sinking on the Oro Hondo property, south of the Homestake, reached a depth of 2,000 feet.

In the Bald Mountain area and the Portland district, the Golden Reward was operated continuously on siliceous ore from its mines and custom ore from the Victoria Extension and the Heidelberg mines. In addition, a considerable quantity of partly oxidized ore was roasted[1] at the Astoria shaft and sent to the mill. These sulphide ores had never before been successfully treated by cyanidation. Sulphide ores of good grade were sent directly to the smelter at Omaha. The Mogul cyanidation mill was operated steadily on company and custom ore with increased capacity.

The annual report[2] of the Mogul Mining Co. for the year 1915 says:

The company milled 31,213 tons of ore and treated 6,206 tons of purchased ores, or a total of 37,419. From this ore were extracted 7,371.7129 ounces of gold, valued at $153,387.64. Silver extracted, 16,493.49 ounces, valued at

[1] For description of roaster see Willard, C. G., The Golden Reward roaster: South Dakota School of Mines Pahasapa Quart., June, 1916, pp. 40–45.
[2] Min. and Eng. World, July 15, 1915, p. 121.

$8,217.44. A larger tonnage than in the previous years was extracted from the company's property and there was a similar increase in the tonnage purchased. The North Lode produced 50 per cent of the ore from company property and was operated on company account, the other workings being mined principally by lessees. The Mark Twain ore was lower in grade; lessees found a few small bodies of good ore in the McDonald; the Oriole, mined close to surface, was disappointingly low in grade; the Passaic work was of prospecting character; the Pluma tailings came from an old chlorination mill dump, of fair grade but yielding poor extraction. The small apparent progress in mine development, shown as 100 feet of the Mill raise and 172 feet in Carstreet tunnel is not a fair measure of the year's preparatory work. This raise is the proposed main working shaft mentioned in previous reports as the outlet for ores from the Ben Hur quartzite level; to start it required much preliminary work. In addition to this work all air-compressing plants were assembled as part of the main power plant at the mill and a trunk air line was extended to the North Lode in one direction and to the Hardscrabble in the other. This work was all classified as mine development, and the total cost, $6,550, was charged off as mine operating. The necessity of diverting funds to other channels prevented further progress in underground work. There was an operating loss of $4,050.53 after charging $6,242.59 to depreciation.

The Reliance and Trojan mills were operated steadily. Some crude ore from the Trojan mine was shipped to the Omaha smelter. Other producing mines were the Alameda, Balmoral, Cherry Gulch, Clinton, Crown Hill, Juno, Marco Polo, Norwich, Ofer (Burlington and Apex claims), and Two Johns.

In the Bear Butte (or Galena) district the new 50-ton cyanidation mill, on the Rattlesnake Jack mine, was operated for a short period.

In the Maitland district development work was done by the North Homestake Mining Co. and by the Echo Gold Mining Co.

In the Yellow Creek district the Wasp No. 2 continued to operate its dry-crushing cyanidation mill; the mine is worked by the open-cut system, a steam shovel being used for stripping. The mill handled 111,300 tons, which yielded $183,488 in cyanide products. This company also sold tungsten to the value of $145,825. A dividend of $82,500 was paid. The company's records for 1911–1915 show:

Operations of Wasp No. 2 Mining Co., 1911–1915.

Year.	Tonnage.	Yield.	Value per ton.	Dividends.
	Short tons.			
1911	160,860	$286,160	$1.779	$60,000
1912	158,840	308,175	1.940	85,000
1913	127,680	219,333	1.718	55,000
1914	176,140	269,979	1.533	30,000
1915	111,300	[a]183,488	1.649	[a]82,500
Total and average value	734,820	1,267,135	1.724	312,500

[a] In addition to the receipts for bullion, this company received $145,825 from the sale of tungsten ore.

The Bismarck mine and mill were idle.

In the Rawlings district, near Tinton, a small yield of placer gold was made from several placers by sluicing, chiefly in Bear Gulch and Potato Creek.

PENNINGTON COUNTY.

Mine production of gold, silver, copper, and lead in Pennington County, S. Dak., 1904–1915.

Year.	Number of mines producing.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	16	1,511	$10,500	274	.....	.....	$10,657
1905	8	11,218	33,096	149	.....	.....	33,186
1906	6	9,281	24,586	335	.....	.....	24,810
1907	7	969	3,190	62	.....	.....	3,231
1908	8	1,235	5,320	72	.....	.....	5,358
1909	13	4,481	14,897	3,208	114,408	.....	31,438
1910	7	943	21,462	84	.....	.....	21,508
1911	16	5,408	31,209	401	.....	.....	31,422
1912	16	341	14,782	101	.....	.....	14,844
1913	5	.....	1,780	13	.....	.....	1,788
1914	8	229	1,664	52	.....	1,131	1,737
1915	10	.....	344	2	.....	.....	345
Increase or decrease [a]	+ 2	−229	−1,320	− 50	.....	−1,131	−1,392

[a] Includes both deep and placer mines.

The dredge at Mystic, on Castle Creek, was moved to the John Day district, Oreg. Development work was done on the Inca mine. At Hill City only development work was done on the lode mines of this district.

In the Hornblende district, near Rochford, assessment work was done on several properties.

Development work only was done in the Keystone district. Several small sluice mines were operated on Battle, Rapid, and Spring creeks. Development work was done on the Grand View property on Rapid Creek.

GOLD, SILVER, AND COPPER IN WYOMING.

(MINES REPORT.)

By Charles W. Henderson.

PRODUCTION.

The total value of the production of gold, silver, and copper in the State of Wyoming for the calendar year 1915 was $93,286, as against only $7,387 in 1914. The yield of all three metals increased materially, particularly copper. There were 12 producing mines, of which 9 were deep and 3 were placer, an increase of 1 deep and a decrease of 4 placer mines, as compared with 1914. The quantity of ore sold or treated was 4,216 tons, as compared with 423 tons in 1914. The deep mines yielded $13,888 in gold, 838 ounces of silver, and 447,246 pounds of copper. The placer-gold production amounted to $704 in 1915, as compared with $1,841 in 1914.

Mine production of gold, silver, and copper in Wyoming in 1914 and 1915.

Year.	Ore.	Gold.[a]		Silver.[a]		Copper.		Total value.
		Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Short tons.	*Fine ounces.*		*Fine ounces.*		*Pounds.*		
1914	423	242.17	$5,006	116	$64	17,421	$2,317	$7,387
1915	4,216	705.89	14,592	840	426	447,246	78,268	93,286
Increase	3,793	463.72	9,586	724	362	429,825	75,951	85,899

[a] Includes placer production.

Mine production of gold, silver, and copper in Wyoming, 1842–1915.[a]

Period.	Gold.	Silver.		Copper.		Total value.
	Value.	Quantity.	Commercial value.	Quantity.	Value.	
		Fine ounces.		*Pounds.*		
1842–1867	(b)					
1867–1870	$396,100	3,170	$4,098			$400,198
1871–1880	400,000	3,240	4,115			404,115
1881–1890	67,500	2,940	3,126	1,395,287	$230,521	301,147
1891–1900	131,700	1,400	943	7,541,647	1,257,649	1,390,292
1901–1910	130,259	45,983	26,896	16,906,466	2,579,095	2,736,250
1911	19,200	725	384	130,499	16,312	35,896
1912	22,235	265	163	25,080	4,138	26,536
1913	24,184	957	578	385,239	59,712	84,474
1914	5,006	116	64	17,421	2,317	7,387
1915	14,592	840	426	447,246	78,268	93,286
	1,210,776	59,636	40,793	26,848,885	4,228,012	5,479,581

[a] For yearly output and authority for each, see U. S. Geol. Survey Mineral Resources, 1912, pt. 1, p. 926, 1913.
[b] Small; unknown.

Mine production of gold and silver in Wyoming in 1914 and 1915, by sources.

Source.	Number of mines.	Ore.	Gold.		Silver.		Total value.
			Quantity.	Value.	Quantity.	Value.	
Deep mines:		*Short tons.*	*Fine oz.*		*Fine oz.*		
Siliceous ore	2	2,997	639.23	$13,214	570	$289	$13,503
Copper ore	6	1,219	32.60	674	268	136	810
Total deep mines—							
1914	8	423	153.11	3,165	109	60	3,225
1915	8	4,216	671.83	13,888	838	425	14,313
Increase		3,793	518.72	10,723	729	365	11,088
Placer mines, 1914	7		89.06	1,841	7	4	1,845
Placer mines, 1915	3		34.06	704	2	1	705
Decrease	4		55.00	1,137	5	3	1,140
Total deep and placer mines, 1915	11	4,216	705.89	14,592	840	426	15,018

MINING INDUSTRY IN WYOMING IN 1915.

The Hartville district, Platte County, was the principal producing district in Wyoming in 1915. Shipments of copper ore from this district increased heavily. Second in importance was the Seminole district, Carbon County, due to the operation of the amalgamation mill on the Penn and King mines. Operations were resumed at the Rambler copper-platinum-palladium property, at Holmes, Albany County, and several cars of ore and concentrates were shipped. The Atlantic City (or South Pass) district, Fremont County, which has been the principal producing district in Wyoming for several years, made a very small production in 1915, one small car of copper ore and a small quantity of placer bullion being shipped. Sluicing operations in the Hurricane district, near Tinton, Crook County, yielded a small quantity of placer gold.

REVIEW BY COUNTIES.[1]

ALBANY COUNTY.[2]

At the Rambler property, at Holmes, the mine and mill were operated during the year, and several cars of ore and concentrates carrying platinum, palladium, copper, silver, and gold were shipped to eastern refineries. Development work was done on several other properties in this district.

Assessment work and development work were done on several claims in the Centennial district.

The following table shows the production of Albany County for earlier years for which figures are available. In 1915 the production

[1] In this review the footnote references indicate publications containing information on the geology of the respective regions.

[2] Emmons, S. F., Platinum in copper ores in Wyoming: U. S. Geol. Survey Bull. 213, pp. 94–97, 1903. Kemp, J. F., Platinum in the Rambler mine, Wyoming: U. S. Geol. Survey Mineral Resources for 1902, pp. 244–250, 1904. Platinum in Wyoming: Eng. and Min. Jour., Mar. 4, 1911, p. 460. Concentration of platiniferous copper ore at the Rambler mine, Wyo.: Met. and Chem. Eng., February, 1911, pp. 75–78.

came from the Rambler mine only, and the statistics, being confidential, can not be shown in this table.

Mine production of gold, silver, and copper in Albany County,[a] Wyo., 1868–1912.

Year.	Ore.	Gold.		Silver.	Copper.
		Placer.	Deep mines.		
	Short tons.			*Fine ounces.*	*Pounds.*
1868–1893	.....	[b] $40,000	[b] $189,000	.....	.....
1901–1912	.....	[c] 945	.....	.....	.....
1901–1903	.....	.....	.....	.....	[c] 900,532
1907	.....	.....	.....	.....	[c d] 24,350
1909–1912	[c e] 3,071	.....	[c] 2,108	[b] 3,213	[c] 700,567

[a] Chiefly Douglas Creek district.
[b] Knight, W. C., The mining districts of Albany County: Wyoming Univ. Agr. College Dept. Bull. 14 p. 128, October, 1893. (Probably too high, considering total production of Wyoming for these years.)
[c] Mineral Resources records.
[d] Beeler, H. C., Mineral resources of Wyoming, State Board of Immigration, Cheyenne, Wyo., p. 27, 1907, gives 828,700 pounds for production of the Rambler mine to date (1907).
[e] For one year tonnage of concentrates used instead of crude ore, giving therefor tonnage and contents of materials smelted. The concentrates were little better than the original crude ore.

BIG HORN COUNTY.[1]

No work was done in this county in 1915.

CARBON COUNTY.[2]

Assessment work was done in the Elk Mountain district.

In the Seminole district, 38 miles northeast of Rawlins, a 20-stamp amalgamation mill was completed in the summer of 1915 on the Penn and King mines. The ore is a gold-bearing oxidized quartz to a depth of 200 feet; below this the sulphide ore carries in addition small quantities of copper and pyrite. The mill was operated steadily beginning October 15.

The Penn-Wyoming mines and smelter, near Encampment, from which much of the copper output of Wyoming has come, were idle.

[1] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Bald Mountain-Dayton folio (No. 141) and Cloud Peak-Fort McKinney folio (No. 142), 1906; Geology of the Bighorn Mountains: U. S. Geol. Survey Prof. Paper 51, 1906. Fisher, C. A., Geology and water resources of Bighorn Basin, Wyo., U. S. Geol. Survey Prof. Paper 53, 1906.

[2] Spencer, A. C., Mineral resources of the Encampment copper region, Wyoming: U. S. Geol. Survey Bull. 213, pp. 158–162, 1903.
Spencer, A. C., Copper deposits of the Encampment district, Wyoming: U. S. Geol. Survey Prof. Paper 25, 107 pp., 1904.
See also Spencer, A. C., Reconnaissance examination of the copper deposits at Pearl, Colo.: U. S. Geol. Survey Bull. 213, pp. 163–169, 1903.

Mine production of gold, silver, and copper in Carbon County,[a] Wyo., 1898–1915.

Year.	Ore.	Gold.	Silver.		Copper.		Total value.
			Fine ounces.	Commercial value.	Pounds.	Value.	
	Short tons.						
1898	[b] 2,484	[b] $497	[b] 314	$185	[c] 233,044	$28,897	$29,579
1899	[b] 33,095	[b] 6,619	[b] 4,183	2,510	[c] 3,104,827	530,925	540,054
1900	[b] 44,808	[b] 8,962	[b] 5,663	3,511	[c] 4,203,776	697,827	710,300
1901	[b] 28,766	[b] 5,753	[b] 3,636	2,182	[cd] 2,698,712	450,685	458,620
1902	[b] 2,536	[b] 507	[b] 321	170	[c d] 237,892	29,023	29,700
1903	[b] 8,250	[b] 1,650	[b] 1,043	563	[c] 773,993	106,037	108,250
1904	41,370	6,593	4,483	2,600	[e] 3,527,008	451,457	460,650
1905	28,039	4,678	3,549	2,165	[e] 2,385,628	372,158	379,001
1906	60				[c] 24,000	4,632	4,632
1907	25,950	4,802	2,982	1,968	[e] 2,206,065	441,213	447,983
1908	18,851	6,181	3,123	1,655	[e] 2,367,666	312,532	320,368
1909	150				[e] 33,431	4,346	4,346
1910							
1911	20		21	11	[e] 4,738	592	603
1912		[f] 27					27
1913		[f] 424	8	5			429
1914	[g] 47	141	26	14	4,439	590	745
1915	[h] 2,976	[h] 12,810	[h] 296	150	[h] 13,074	2,288	15,248
	237,402	59,644	29,648	17,689	21,818,293	3,433,202	3,510,508

[a] From 1898 to 1909 this is almost entirely the production of the Encampment district, there being only small yields from other districts of Carbon County.
Average per ton of ore 1898 to 1909: Gold, $0.199; silver, 0.129 ounce; copper, 93 pounds, or 4.62 per cent.
[b] Estimated by Charles W. Henderson.
[c] Smelter figures.
[d] The Encampment production for 1901–2 is the total Wyoming copper production less the Douglas Creek, Albany County, copper production. The Douglas Creek figures are available only for the two years combined. This combined production has been subtracted from the total Wyoming production for 1902, none being subtracted from the 1901 figures. In either event, the total pounds of copper produced in each camp would be unchanged.
[e] Mine figures.
[f] Placer output.
[g] Saratoga and Seminole districts.
[h] Seminole and Elk Mountain districts.

CONVERSE COUNTY.

No work was done at the Saul's Camp property, near Esterbrook.

CROOK COUNTY.

A small quantity of gold was produced from sluicing operations in the Hurricane district, northwest of Tinton, S. Dak.

Assessment work only was done on properties in the Bear Lodge district,[1] near Sundance.

FREMONT COUNTY.

Atlantic City (South Pass) district.[2]—This district was discovered in 1842, but very little production was made until 1867. From 1867 to 1875[3] (when the district was known as the Sweetwater district) there was considerable activity. Both placer and lode mines were productive, the placers being worked by sluicing and the lode mines

[1] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Sundance folio (No. 127), 1905.
[2] Trumbull, L. W., Atlantic City gold mining district, Fremont County, Wyo.: Wyoming State Geologist Rept. Bull. 7, ser. B, 1914.
Spencer, A. C., Atlantic Gold district and North Laramie Mountains, Wyo.: U. S. Geol. Survey Bull. 626, 1916.
[3] See note to table of production of gold, silver, and copper in Wyoming, 1842–1914, U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 248, 1915.

by stamp amalgamation. In 1875 the district was practically idle and from then on very little work was done for years. During 1911–1913 there was a reopening of mines in this district, and an increasing production was shown for these years, due to the installation of amalgamation-cyanidation mills, but in 1914 the principal producing property was idle, and in 1915 only a small quantity of placer gold was produced and one small shipment of copper ore was made from Lewiston, in the southern part of the district. The hydraulic plant of the X. L. Gold Dredging Co. was not operated.

Copper Mountain district.—No work was done on the prospects in this district in 1915.

Gold placers on Wind and Bighorn rivers.[1]—No yield was made from these deposits.

JOHNSON COUNTY.[2]

Assessment work was done in the Big Goose and Bull Camp districts and in the Kelly Creek district.

A small test run was made in the 5-stamp amalgamation mill on the La Porte property.

LARAMIE COUNTY.

In the Comstock district, near Hecla, several cars of gold-silver-copper ore were shipped from the Comstock mine. This property is opened by a vertical shaft 300 feet deep and by drifts 170 feet long. The mine was operated practically all the year 1915, and the shaft was extended 125 feet during the year.

A car of copper ore was also shipped from the Copper King mine.

LINCOLN COUNTY.[3]

Development work was done on the Golden Eagle prospect, near Kemmerer.

NATRONA COUNTY.

In the Casper Mountain district, 10 miles south of Casper, the Nettie M. claim, from which a car of copper ore was shipped from the surface in 1914, was abandoned.

PARK COUNTY.

Assessment work only was done in the Sunlight and Kirwin[4] districts of Park County.

PLATTE COUNTY.[5]

A large quantity of copper ore was shipped from the Sunrise iron mine, near Sunrise, in the Hartville district.[6] Shipments of copper ore were also made from the Copper Bottom and Green Hope mines.

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[1] Schrader, F. C., Gold placers on Wind and Bighorn rivers, Wyo.: U. S. Geol. Survey Bull. 580, pp. 127–145, 1915.

[2] Darton, N. H., U. S. Geol. Survey Geol. Atlas, Bald Mountain-Dayton folio (No. 141) and Cloud-Peak-Fort McKinney folio (No. 142), 1906; also Geology of the Bighorn Mountains, U. S. Geol. Survey Prof. Paper 51, 1906.

[3] Schultz, A. R., Gold developments in central Uinta County, Wyo., and at other points on Snake River: U. S. Geol Survey Bull. 315, pp 71–88, 1907.

[4] Hewett, D. F., The ore deposits of Kirwin, Wyo.: U. S. Geol. Survey Bull. 540, pp. 121–132, 1914.

[5] The northern part of Laramie County prior to 1913.

[6] Smith, W. S. T., U. S. Geol. Survey Geol. Atlas, Hartville folio (No. 91), 1903. Ball, S. H., Copper deposits of the Hartville uplift, Wyoming: U. S. Geol. Survey Bull. 315, pp. 93–107, 1907.

Mine production of silver and copper in the Hartville district, Platte County, Wyo., 1882–1915.[a]

Year.	Ore.	Silver.		Copper.		Total value.
		Quantity.	Commercial value.	Quantity.	Value.	
	Short tons.	*Fine ounces.*		*Pounds.*		
1882		[b] 140	$160	100,000	$19,100	$19,260
1883		[b] 1,340	1,487	962,468	158,807	160,294
1888		[b] 320	301	232,819	39,114	39,415
1889		[b] 140	132	100,000	13,500	13,632
1882–1889	[c] 4,651	[b] 1,940	2,080	1,395,287	230,521	232,601
1907–1909, 1911–12	[d] 539	[e] 342	188	172,875	23,127	23,315
1913	[d] 964	831	562	385,239	59,712	60,214
1914	30	45	25	10,042	1,336	1,361
1915	914	55	28	415,394	72,694	72,722
	7,098	3,213	2,823	2,378,837	387,390	390,213

[a] For basis of figures, see Kirchhoff, C., jr., The copper industry of the United States: U. S. Geol. Survey Mineral Resources for 1881–82, pp. 216, 229, 1883; idem for 1883–84, p. 329, 1885. Knight, W. C., The Hartville district: Wyoming Univ. Agr. Coll. Dept. Bull. 14, pp. 135–136, October, 1893.

[b] Estimated by Charles W. Henderson on Mr. Kirchhoff's statement that ore contained ⅓ to ½ ounce of silver for every per cent of copper.

[c] Estimated on basis of 15 per cent copper per ton (Kirchhoff).

[d] Mineral Resources records collected from the mines.

[e] Mineral Resources records 1911–12. Estimated on 1911–12 record for 1907, 1908, 1909.

SHERIDAN COUNTY.

Assessment work was done on the Black Mountain prospect, in the Black Mountain district.

UINTA COUNTY.[1]

In 1915 the greater part of the area of this county was separated into the new county of Lincoln, only the more populous southern area remaining in Uinta County.

No production was reported in 1915 from Lincoln or Uinta counties.

[1] Schultz, A. R., Gold developments in central Uinta County, Wyo., and at other points on Snake River: U. S. Geol. Survey Bull. 315, pp. 71–88, 1907.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN NEW MEXICO.[1]

(MINES REPORT.)

By Charles W. Henderson.

PRODUCTION.

The value of the gold, silver, copper, lead, and zinc produced from ores and gravels in New Mexico in 1915, as reported from 174 productive mines, 26 of which were placers, amounted to $19,279,468. As compared with $11,049,932 in 1914, this is an increase in value for 1915 of $8,229,536. The yield of gold was 70,680.96 fine ounces, valued at $1,461,105, an increase of 14,000.17 fine ounces in quantity and of $289,409 in value. The yield of silver was 2,005,531 fine ounces, valued at $1,016,804, an increase of 228,086 fine ounces in quantity and of $33,877 in value. The output of copper was 76,788,366 pounds, an increase of 17,480,441 pounds; the output of lead (calculated as lead in lead bullion and lead in zinc-lead oxide) was 4,542,361 pounds, an increase of 2,778,720 pounds; and the output of zinc (calculated as spelter and zinc in zinc-lead oxide) was 25,404,064 pounds, an increase of 7,000,672 pounds. The value of the base metals showed an increase of $5,550,010 for copper, of $144,709 for lead, and of $2,211,531 for zinc (valued at the average yearly price of spelter for each year). There were 2,797,072 short tons of ore sold or treated in 1915, as compared with 2,232,853 short tons in 1914.

Mine production of metals in New Mexico, 1904–1915.

Year.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc.	Total value.
	Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	102,339	$381,930	214,553	4,972,170	3,122,872	13,493,835	$1,961,390
1905	145,629	317,510	369,192	6,126,025	1,510,209	15,142,254	2,460,535
1906	207,691	293,019	491,127	7,028,670	2,987,369	17,292,655	3,203,739
1907	219,992	329,982	705,544	10,990,015	3,809,881	750,085	3 239,823
1908	135,434	298,757	405,044	6,112,630	873,763	3,576,516	1,525,091
1909	164,156	239,491	397,783	5,393,146	5,029,767	13,085,945	2,070,368
1910	191,865	482,424	843,987	4,614,386	4,320,841	18,088,129	2,691,080
1911	232,699	762,808	1,354,540	4,057,040	2,966,222	10,237,176	2,704,843
1912	1,352,286	784,446	1,536,701	34,030,964	5,494,018	13,566,637	8,527,955
1913	2,217,660	881,926	1,631,273	56,308,706	3,946,364	16,523,161	11,694,002
1914	2,232,853	1,171,696	1,777,445	59,307,925	1,763,641	18,403,392	11,049,932
1915	2,797,072	1,461,105	2,005,531	76,788,366	4,542,361	25,404,064	19,279,468
Increase	564,219	289,409	228,086	17,480,441	2,778,720	7,000,672	8,229,536

[a] Includes placer production.

During 1915 there were treated at amalgamating and cyaniding mills in New Mexico 149,650 tons of ore, and the bullion saved amounted to $836,679 in gold, an average value per ton of $5.59, and 1,129,701 ounces of silver, valued at $572,758, an average recovery per ton of 7.55 ounces, and an average value of $3.83, the value in

[1] For discussion of the geology of the districts mentioned in the following pages the reader is referred to the bibliography appended to the report for 1912, in Mineral Resources for 1912, pt. 1, p. 819, 1913, and to U. S. Geol. Survey Bull. 507, The mining districts of the western United States, by J. M. Hill, with a geologic introduction by Waldemar Lindgren, 1912.

gold and silver being $1,409,437, an average value per ton of $9.42. The recovery as bullion per ton of ore treated in 1914 was $3.92 in gold and $4.09 in silver, a total of $8.01.

GOLD.

The recoverable production of gold from New Mexico ores and gravels in 1915 amounted to 70,680.96 fine ounces, valued at $1,461,105, as against 56,680.79 fine ounces, valued at $1,171,696, in 1914, an increase of 14,000.17 fine ounces in quantity and of $289,409 in value. Socorro County alone produced 24,654.47 fine ounces, valued at $509,653, or 35 per cent of the total State yield (this was almost entirely from the siliceous ore mines at Mogollon); Colfax, Lincoln, and Sandoval counties combined produced 23,311.09 fine ounces, valued at $481,883, or 33 per cent of the total State yield; and Grant County produced 17,660.89 fine ounces, valued at $365,083, or 25 per cent of the total. Dry and siliceous ores yielded 51,659.88 fine ounces, valued $1,067,904, or 73 per cent of the total. Copper ores contained 18,221.02 fine ounces, valued at $376,662, or 26 per cent of the total, chiefly from Central, Lordsburg, and Pinos Altos districts, Grant County. Lead ores furnished 247.39 fine ounces, valued at $5,114, chiefly from Pinos Altos district, Grant County. Copper-lead ores furnished a negligible percentage of the total gold. The production of placer gold amounted to 447.09 fine ounces, valued at $9,242.

SILVER.

The recoverable yield of silver from New Mexico ores in 1915 amounted to 2,005,531 fine ounces, valued at $1,016,804, as compared with 1,777,445 fine ounces, valued at $982,927, in 1914, an increase for 1915 of 228,086 fine ounces in quantity and of $33,877 in value. Of the total, Socorro County produced 1,358,000 fine ounces, or 68 per cent, chiefly from siliceous ore from the Mogollon district, the remainder from mixed ores of the Magdalena district. Grant County furnished 508,552 ounces, or 25 per cent of the total, chiefly from the Lordsburg district. The yield of silver from Grant and Socorro counties combined was 93 per cent of the total.

Dry and siliceous gold and silver ore, chiefly from Socorro and Grant counties, yielded 1,431,350 fine ounces of silver, or 71 per cent of the total; copper ores, chiefly from Grant, Socorro, and Santa Fe counties, yielded 513,288 ounces, or nearly 26 per cent; lead ores, chiefly from the Central and San Simon districts, Grant County, and from the Magdalena district, Socorro County, furnished 48,371 ounces, or 2 per cent; and copper-lead ores, chiefly from Grant and Socorro counties, furnished 11,044 ounces, or less than 1 per cent.

COPPER.

In 1915 the production of copper in New Mexico amounted to 76,788,366 pounds, valued at $13,437,964, an increase of 17,480,441 pounds and $5,550,010, as compared with the output of 1914. Grant County, chiefly from the output of the Chino Copper Co., at Santa Rita, and from Lordsburg and Pinos Altos, produced 72,487,200 pounds, or 94 per cent of the total. The increase for the year in Grant County was 14,228,087 pounds. The yield from Dona Ana County increased 163,569 pounds; that from Otero County, 454,432 pounds; that from Santa Fe, 1,411,497 pounds; and that from Socorro

County, 1,201,376 pounds. Shipments of copper ore from the new district in Torrance County, north of Scholle and west of Mountainair, produced 25,143 pounds.

Copper ores, chiefly from Dona Ana, Grant, Otero, Santa Fe, and Socorro counties, yielded 76,153,386 pounds, or 99 per cent of the total; dry and siliceous gold and silver ore (chiefly from the dry ore of Otero County and from the siliceous ore of Lordsburg district, Grant County), yielded 467,093 pounds, or less than 1 per cent; lead ores, chiefly from the Central district, Grant County, and the Magdalena district, Socorro County, yielded 78,372 pounds; and copper-lead ores, chiefly from Dona Ana, Grant, and Socorro counties, 74,419 pounds.

There were 10,461,812 pounds of copper contained in crude ore shipped to smelters, or 14 per cent of the total production, and concentrates contained 66,326,554 pounds, or 86 per cent.

LEAD.

The production of lead increased from 1,763,641 pounds in 1914 to 4,542,361 pounds in 1915. The output in 1915 was valued at $213,491.

The chief lead-producing districts were the Central, San Simon, and Pinos Altos district, Grant County; the Magdalena district, Socorro County, and the Cooks and Victorio districts, Luna County. Grant County yielded 2,251,383 pounds; Socorro County, 2,033,723 pounds, and Luna County, 148,766 pounds. Concentrates contained 75,580 pounds, and crude ore to smelters contained 4,466,781 pounds. Lead ores furnished 3,910,786 pounds; zinc and lead-zinc ores, 342,150 pounds, and copper-lead ores, 208,003 pounds—the combined content representing 98 per cent of the total.

ZINC.

The total recoverable zinc, whether marketed as spelter or as oxide, from crude ore and concentrates shipped from New Mexico in 1915 and calculated in terms of spelter and zinc in zinc oxide, was 25,404,064 pounds, valued (in terms of average price of spelter for the year) at $3,150,104. In terms of marketable metal, the value of the zinc contained in ore from New Mexico in 1915 was $2,133,300 more than the silver output and $1,688,999 more than the gold yield.

Mines producing zinc in New Mexico in 1914 were at Kelly, Socorro County; in the Central and Pinos Altos districts, Grant County; Cooks, Florida, and Tres Hermanas districts, Luna County; Cerrillos district, Santa Fe County; and Hermosa district, Sierra County.

Zinc ore and concentrates marketed in New Mexico, 1914–15, and average assay of zinc.

Year.	Quantity (short tons).	Average assay (per cent).
1914	29,459	37.53
1915	41,852	36.60
Increase	12,393	

CONTENT OF ORES.

Content of copper ores sold or treated in New Mexico in 1915.

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*
Colfax	34	0.36	88	14,092	.....
Dona Ana	1,488	117.27	7,105	232,931	2,297
Grant	2,502,999	15,706.90	443,264	72,237,508	22,282
Lincoln	2	.13	33	843	139
Luna	32	.32	364	2,669	.....
Otero	7,921	349.61	2,338	553,720	.....
Rio Arriba	2	.29	416	423	.....
Sandoval	54	.....	111	14,657	.....
Santa Fe	27,005	2,008.52	23,936	1,702,932	.....
Sierra	13	37.40	236	1,809	129
Socorro	12,871	.22	35,273	1,366,659	672
Torrance	188	.....	124	25,143	.....
	2,552,609	18,221.02	513,288	76,153,386	25,519

Content of dry and siliceous gold and silver ores sold or treated in New Mexico in 1915.

County.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*
Colfax	2,639	16,966.93	2,380	.....	787	.....
Grant	4,211	1,552.20	29,903	144,573	2,052	.....
Lincoln	8,504	2,131.66	246	.....	.....	.....
Luna	60	.....	116	1,411	.....	.....
Otero	8,707	2,310.00	3,917	319,028	.....	.....
Sandoval	18,647	4,021.46	93,203	.....	.....	.....
Santa Fe	708	28.06	431	1,925	50,638	14,556
Sierra	5	14.79	18	156	.....	.....
Socorro	119,710	24,630.86	1,301,059	.....	2,426	.....
Taos	50	3.92	77	.....	.....	.....
	163,241	51,659.88	1,431,350	467,093	55,903	14,556

Content of lead ores sold or treated in New Mexico in 1915.

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*
Dona Ana	26	0.09	57	.....	6,812
Grant	4,129	214.80	29,385	39,788	2,063,908
Luna	330	23.43	2,315	.....	148,766
Sierra	403	.....	58	263	24,488
Socorro	3,931	9.07	16,556	38,321	1,666,812
	8,819	247.39	48,371	78,372	3,910,786

Content of zinc and lead-zinc ores sold or treated in New Mexico in 1915.

County.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*
Grant and Luna	13,109	17.00	1,423	15,096	.....	6,944,798
Sierra	17	.....	.....	.....	.....	7,492
Socorro	58,535	.....	.....	.....	342,150	18,437,218
	71,661	17.00	1,423	15,096	342,150	25,389,508

Content of copper-lead ores sold or treated in New Mexico in 1915.

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*
Dona Ana	85	.....	1,173	8,818	10,061
Grant	487	74.25	4,549	50,235	163,141
Lincoln	44	.....	210	4,248	13,138
Socorro	126	14.33	5,112	11,118	21,663
	742	88.58	11,044	74,419	208,003

SMELTERS.

Within the borders of New Mexico there was one smelter in operation, the Santa Fe Gold & Copper Co.'s 125-ton matting plant at San Pedro, which was operated on copper ore from its own mines.

The bulk of the smelting lead and copper ores and concentrates continued to be shipped to the El Paso (Tex.) smelter.[1] Some ore and concentrates were shipped to Pueblo, Colo. Shipments were also made to the Copper Queen smelter, at Douglas, Ariz., to the Calumet and Arizona smelter, at Douglas, Ariz., and to the Hayden smelter, at Hayden, Ariz. Bullion and ore was shipped to Selby, Cal. Zinc ore and concentrates were shipped to smelters and zinc oxide plants in Kansas, Oklahoma, Wisconsin, and eastern points.

MINING INDUSTRY.

The Mogollon district, Socorro County (reached at present from the railroad point Silver City, Grant County, a distance of 80 miles), maintained its position as the most productive district in New Mexico in gold and silver with an output of $509,165 in gold and 1,301,059 ounces of silver, a decrease of $119,937 in gold and of 109,268 ounces of silver, as compared with the output in 1914. The gold from this district in 1915 represented 35 per cent of the State's production of this metal, and the silver was 65 per cent of the State's total output. The Cleaveland & Weatherhead mine and custom mill were idle the entire year; but the Mogollon Mines Co.'s mill was operated steadily on ore from the company's Last Chance and Top mines and the Fanney mill, of the Socorro Mining & Milling Co., was operated steadily on ore from the company's mine and from various other properties in the district. The product of the mills is chiefly refined silver-gold bullion from cyanide precipitates, the balance being high-grade gold-silver concentrates. In terms of recovered metal, the ore averaged per ton 0.2058 ounce, or $4.25, in gold and 10.87 ounces, or $5.51, in silver. The second district in the production of gold was the Elizabethtown district, Colfax County, there being a small quantity of placer gold and an important quantity of high-grade metallic gold, gold bullion, and concentrates from the Aztec mine, at Baldy. No high-grade gold such as was found in pockets in 1914 was uncovered in the Pinos Altos district in 1915. This district, however, in 1915 again became an important producer of zinc, owing to the completion and operation of the new magnetic separation mill at the Cleveland mine in December, and it will be a very important factor in the production of zinc in the State in 1916. Continuous output of gold bullion was made from the amalgamation mill at the North and South Homestake mines, at Whiteoaks, Lincoln County. A small output of gold was made from the Gold Hill district, north of Lordsburg, and shipments of gold-silver ore were made from the reopened camp of Steeplerock, Grant County. The Lordsburg district, Grant County, more than doubled its shipments of siliceous gold and silver bearing copper and dry ores, which yielded $222,848 in gold and 374,325 ounces of silver, an increase of $121,768 in gold and of 141,678 ounces of silver. The small gold credit in the copper concentrates of the Chino Copper Co., which amounted to 3.35 cents per ton of original crude ore treated, as compared with 2.71 cents per ton of original crude ore

[1] Easter, H. F., Lead smelting at El Paso: Am. Inst. Min. Eng. Bull. 104, pp. 1493–1506, 1915.

in 1914, aggregated 3,991 ounces of gold in 1915, for which the company was paid $20 an ounce. The reopening of the mines and matte smelter of the Santa Fe Gold & Copper Co., at San Pedro, Santa Fe County, in May, 1915, and its continuous operation throughout the year, added a considerable quantity of gold to the yield in New Mexico. Increased shipments of gold-copper ores from the Jarilla district, Otero County, also contributed to the gold increase. The 100-ton cyanidation plant of the Cossak Mining Co., which commenced operations in September, 1914, in the Cochiti (Bland) district, Sandoval County, was operated continuously until December and had an important output of silver-gold bullion.

The production of copper in New Mexico continued to increase. The Chino Copper Co., which has been mining, since 1910, with steam shovels, a large acreage of low-grade copper deposits at Santa Rita, and milling an average of 6,520 tons of ore per day during 1915 at Hurley, in a wet-concentration mill of five sections, treated a total for the year of 2,379,800 tons, this being the largest quantity of ore treated in any year since the beginning of operations. This large increase in quantity was made possible by the completion of the installation of additional power and by the changes made in the mill and in concentrating methods, part of which change was the installation of the froth flotation method. The total production of concentrates was 158,444 tons, corresponding to a ratio of concentration of 15 tons of ore to produce 1 ton of concentrates. The total quantity of copper contained in concentrates was 68,293,893 pounds, corresponding to an average concentrate grade of 21.55 per cent copper, representing an extraction of 66.588 per cent of the copper content. The copper output of Lordsburg, Grant County, in 1915 increased 50 per cent, and the yield was the largest in the history of that district. The mines and 125-ton matting plant at San Pedro, Santa Fe County, were operated continuously from May throughout the year, as compared with one month's operation in 1914. The output of copper from the Jarilla district, Otero County, increased 50 per cent. The Burro Mountain Copper Co.'s 1,000-ton mill, in the Burro Mountain district, was not finally completed and operated until 1916, but lessees' shipments of smelting ore and shipments of concentrates and copper precipitates from the company's experimental mill contributed an increased yield of copper from this district. A large quantity of low-grade copper ore, having calcite gangue, was shipped from the Apache mine, Hachita. An increased yield of copper was made in the Organ district, Dona Ana County.

The output of lead showed an appreciable increase. Lead ores were shipped from the Cooks Peak and Tres Hermanas districts, Luna County; from the Central, San Simon, and Pinos Altos districts, Grant County; and from the Magdalena district, Socorro County.

Heavily increased shipments of zinc carbonate and sulphide ores and zinc sulphide concentrates were made from New Mexico in 1915. At Kelly, Socorro County, the principal producing mines were the Kelly, Graphic, and Juanita. The Ozark flotation mill was operated continuously on the sulphide ores from the Graphic mine. The Kelly magnetic mill was completed. Zinc carbonate and zinc-lead carbonate ores were shipped to smelters from Kelly. Zinc carbonate ores were shipped from the Hanover mine of the Empire Zinc Co., and from other properties at Hanover, and the building of a mill for the treatment of sulphide ores at Hanover was begun. Both zinc

carbonate and sulphide ores were shipped from the Cooks Peak district, and zinc carbonate from the Florida and Tres Hermanas districts, Luna County. Zinc sulphide concentrates were shipped from the wet-concentration-electrostatic mill of the Pinos Altos Mining & Milling Co. A new magnetic separation mill at the Cleveland mine, at Pinos Altos, was completed in November, and zinc concentrates were shipped during December and thereafter. A car of zinc ore was shipped from the Hermosa district, Sierra County, and a shipment of zinc concentrates was made from the Tom Payne property, at Los Cerrillos. The production of zinc ore and concentrates from New Mexcio was 41,852 tons of 36 per cent zinc, as compared with 29,459 tons of 37.53 per cent in 1914.

COMMERCIAL VALUE OF MINERAL OUTPUT.

The State tax commission of New Mexico has made public the figures on the commercial production of the State that were obtained under the provisions of the Springer-Hawkins mine-tax law, passed by the legislature in 1915. The figures are given below.

Commercial value of metal output in New Mexico in 1915.

County.	Gross returned by operators.	Net value as determined by State tax commission.
Colfax County:		
Maxwell Land Grant Co., Baldy	$343,950.90	$291,191.00
Dona Ana County:		
A. Roos, sublessee, Organ Mountains	7,592.08	1,023.00
B. F. Farrar, lessee, Organ Mountains	4,304.97	654.00
	11,897.05	1,677.00
Grant County:		
Chino Copper Co., Santa Rita	11,383,777.48	6,846,204.00
Hanover-Bessemer Iron & Copper Co., Fierro	Royalty.	10,000.00
Eighty-five Mining Co., Lordsburg	762,921.78	183,689.00
Burro Mountain Copper Co., Burro Mountain	72,059.29	17,152.00
Empire Zinc Co., Hanover and Pinos Altos	420,558.96	358,233.00
H. R. Brandenburg, lessee	13,199.93	2,937.00
Wiggins & Hill, lessees, Lordsburg	7,169.54	914.00
	12,659,686.98	7,419,129.00
Lincoln County:		
Wild Cat Leasing Co., Whiteoaks	49,611.82	9,688.00
Whiteoaks Mines Consolidated, Whiteoaks	30,259.63	17,008.00
	79,871.45	26,696.00
Luna County:		
Cooks Peak Mining Co., Cooks Peak	10,110.01	7,365.00
Otero County:		
Jarilla Copper Syndicate, Orogrande	67,897.50	10,891.00
James Douglas, trustee, El Paso & Southwestern Ry	Royalty.	3,446.00
Oro Iron Co., Orogrande	36,852.23	9,324.00
G. E. Moffett, lessee, Orogrande	6,815.72	277.00
	111,565.45	23,938.00
Sandoval County:		
Cossak Mining Co., Bland	128,778.48	23,000.00
Socorro County:		
Mines & Metals Co. (Ambrosia mine), Kelly	6,217.06	4,091.00
Mines & Metals Co. (Juanita mine), Kelly	28,536.88	17,786.00
Empire Zinc Co., Kelly	114,020.46	98,881.00
Mogollon Mines Co., Mogollon	508,502.36	134,485.00
Socorro Mining & Milling Co., Mogollon	619,127.44	180,154.00
Struppi lease, Ozark Smelting & Mining Co., Kelly	53,403.09	27,300.00
Exter, Long & Combs, lessees, Empire Zinc Co., Kelly	5,291.13	779.00
Ozark Smelting & Mining Co., Kelly	Not given.	Not given.
	1,335,098.42	463,476.00
Grand total	14,680,958.74	8,256,472.00

The figures on gross production are those returned to the commission by the operators, but the net values, on which taxes are collected, were determined by the commission after an examination not only of the returns made, but of reports submitted by a special accountant, who checked the operators' books * * *.

Under the provisions of the Springer-Hawkins mine-tax law the mines and mineral lands of the State are divided into productive and nonproductive classes. On the net outputs of the producing properties taxes are assessed as on all other property, and these taxes are considered to cover the full mineral values of the lands being worked, and of contiguous lands held for future extensions of the mining operations. The net value of the mineral output is stated to mean the difference between the actual cost of production, transportation, treatment, shipment, and sale, and the amount realized, if sold, or which could be realized at the time of making the reports, and it is specified that the statements of expenditures shall not include any amounts expended for machinery or other improvements, for the construction of mills or other reduction works, or for salaries of persons not actually engaged in the working of the mines in the reduction, transportation, or marketing of the minerals, or in the personal management of the enterprises. All nonproductive mineral lands are to be assessed and taxed on the reasonable valuation thereof as undeveloped mineral ground, in addition to their surface values for grazing, agriculture, timber, or other purposes, and in fixing such values it is the duty of the taxing officials to take into consideration transportation problems and opportunities for marketing the products. The law does not exempt from taxation reduction works, buildings, and other improvement at mines or mineral lands.[1]

Mine production of metals in New Mexico in 1915.

County.	Number of mines producing.	Ore.	Gold.[a]		Silver.[a]	
			Quantity.	Value.	Quantity.	Value.
		Short tons.	*Fine ounces.*		*Fine ounces.*	
Colfax	5	2,673	17,094.56	$353,376	2,483	$1,259
Dona Ana	5	1,599	117.36	2,426	8,335	4,226
Grant	87	2,523,275	17,660.89	365,083	508,552	257,836
Lincoln	7	8,550	2,195.07	45,376	493	250
Luna	14	2,082	23.75	491	2,795	1,417
Otero	15	16,628	2,659.61	54,979	6,255	3,171
Rio Arriba	1	2	.29	6	416	211
Sandoval	2	18,701	4,021.46	83,131	93,314	47,310
Santa Fe	13	27,713	2,112.39	43,667	24,371	12,356
Sierra	8	438	137.19	2,836	316	160
Socorro	11	195,173	24,654.47	509,653	1,358,000	688,506
Taos	1	50	3.92	81	77	39
Torrance	5	188	.....	.....	124	63
Total, 1915	174	2,797,072	70,680.96	1,461,105	2,005,531	1,016,804
Total, 1914	139	2,232,853	56,680.79	1,171,696	1,777,445	982,927
Increase	35	564,219	14,000.17	289,409	228,086	33,877

County.	Copper.		Lead.		Zinc.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Colfax	14,092	$2,466	787	$37	.....	.....	$357,138
Dona Ana	241,749	42,306	19,170	901	.....	.....	49,859
Grant	72,487,200	12,685,260	2,251,383	105,815	(b)	(b)	13,413,994
Lincoln	5,091	891	13,277	624	.....	.....	47,141
Luna	4,080	714	148,766	6,992	(b)	(b)	9,614
Otero	872,748	152,731	.....	.....	.....	.....	210,881
Rio Arriba	423	74	.....	.....	.....	.....	291
Sandoval	14,657	2,565	.....	.....	.....	.....	133,006
Santa Fe	1,704,857	298,350	50,638	2,380	14,556	$1,805	358,558
Sierra	2,228	390	24,617	1,157	7,492	929	5,472
Socorro	1,416,098	247,817	2,033,723	95,585	18,437,218	2,286,215	3,827,776
Taos	.....	.....	.....	.....	.....	.....	120
Torrance	25,143	4,400	.....	.....	.....	.....	4,463
Grant and Luna	.....	.....	.....	.....	6,944,798	861,155	861,155
Total, 1915	76,788,366	13,437,964	4,542,361	213,491	25,404,064	3,150,104	19,279,468
Total, 1914	59,307,925	7,887,954	1,763,641	68,782	18,403,392	938,573	11,049,932
Increase	17,480,441	5,550,010	2,778,720	144,709	7,000,672	2,211,531	8,229,536

[a] Includes placer production.

[b] In order to avoid disclosing individual production, the production of zinc in Grant and Luna counties is combined.

[1] Min. and Eng. World, Apr. 1, 1916, p. 356.

Ore sent to gold and silver mills and concentrating mills, with quantity of gold and silver in bullion produced in New Mexico from 1909 to 1915, inclusive.

Year.	Ore to gold and silver mills.	Gold in bullion.	Silver in bullion.	Ore to concentrating mills.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Short tons.*
1909	32,830	6,725.84	169,650	78,782
1910	67,148	14,220.94	412,272	61,379
1911	109,113	21,894.14	771,014	59,622
1912	106,208	20,342.58	842,018	1,142,002
1913	124,536	24,891.37	1,024,363	1,987,896
1914	156,913	29,730.64	1,161,455	1,955,881
1915	149,650	40,474.37	1,129,701	2,428,344
Increase or decrease	−7,263	+10,743.73	−31,754	+472,463

Mine production of metals from New Mexico concentrates from 1909 to 1915, inclusive.

Year.	Concentrates produced.					
	Quantity.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
1909	7,554	1,598.31	112,639	2,015,118	436,558	821,766
1910	18,298	4,536.03	255,060	1,050,238	2,701,843	6,882,175
1911	16,243	7,938.70	333,654	1,125,927	1,562,768	5,304,000
1912	81,811	7,190.63	290,081	28,760,908	1,984,435	6,404,768
1913	198,243	7,913.39	294,948	51,723,923	1,076,848	8,594,183
1914	161,003	12,754.17	312,734	53,398,611	637	8,541,261
1915	174,074	12,876.72	323,402	66,326,554	75,580	11,179,266
Increase	13,071	122.55	10,668	12,927,943	74,943	2,638,005

Mine production of metals from New Mexico crude ore shipped to smelters from 1909 to 1915, inclusive.

By years.

Year.	Crude ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
1909	52,544	2,196.50	115,332	3,378,028	4,593,209	12,264,179
1910	63,338	3,317.99	176,281	3,564,148	1,618,998	11,205,954
1911	63,964	6,162.71	249,710	2,931,113	1,403,454	4,933,176
1912	104,076	9,595.57	404,462	5,270,056	3,509,583	7,161,869
1913	105,228	9,478.13	311,872	4,584,783	2,869,516	7,928,978
1914	120,059	12,785.76	302,926	5,909,314	1,763,004	9,862,131
1915	219,078	16,882.78	552,373	10,461,812	4,466,781	14,224,798
Increase	99,019	4,097.02	249,447	4,552,498	2,703,777	4,362,667

By kinds of ore.

Dry and siliceous	12,891	3,235.96	33,078	465,327	2,052	.....
Copper	169,983	13,310.85	459,917	9,843,957	25,519	.....
Lead	8,419	247.39	48,334	78,109	3,889,057	.....
Copper-lead	742	88.58	11,044	74,419	208,003	.....
Zinc and lead-zinc	27,043	.....	.....	.....	342,150	14,224,798

Mine production of metals from New Mexico crude ore and concentrates combined shipped to smelters from 1909 to 1915, inclusive.

Year.	Ore.	Gold.	Silver.	Coppr.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
1909	60,098	3,794.81	227,971	5,393,146	5,029,767	13,085,945
1910	81,636	7,854.02	431,341	4,614,386	4,320,841	18,088,129
1911	80,207	14,101.41	583,364	4,057,040	2,966,222	10,237,176
1912	185,887	16,786.20	694,543	34,030,964	5,494,018	13,566,637
1913	303,471	17,391.52	606,820	56,308,706	3,946,364	16,523,161
1914	281,062	25,539.93	615,660	59,307,925	1,763,641	18,403,392
1915	393,152	29,759.51	875,775	76,788,366	4,542,361	25,404,064
Increase	112,090	4,219.58	260,115	17,480,441	2,778,720	7,000,672

Ore sent to gold and silver mills and concentrating mills and quantity of gold and silver bullion produced in New Mexico in 1915.

County.	Ore to gold and silver mills.	Gold.	Silver.	Ore to concentrating mills.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Short tons.*
Colfax	2,639	13,674.37	1,856	.....
Grant	100	662.94	882	2,383,323
Lincoln	8,504	2,131.66	246	.....
Otero	.....	.....	.....	1,620
Sandoval	18,647	4,021.46	93,203	.....
Santa Fe	.....	.....	.....	700
Sierra	.....	.....	.....	400
Socorro	119,710	19,980.02	1,033,437	42,301
Taos	50	3.92	77	.....
	149,650	40,474.37	1,129,701	2,428,344

Mine production of metals from New Mexico crude ore shipped to smelters in 1915.

County.	Crude ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Colfax	34	0.36	88	14,092	.....	.....
Dona Ana	1,599	117.36	8,335	241,749	19,170	.....
Grant	139,852	11,975.04	452,873	6,173,786	2,251,383	(a)
Lincoln	46	.13	243	5,091	13,277	.....
Grant, Luna, and Socorro	.....	.....	.....	.....	.....	a14,217,306
Luna	2,082	23.75	2,795	4,080	148,766	(a)
Otero	15,008	2,659.61	6,232	861,637	.....	.....
Rio Arriba	2	.29	416	423	.....	.....
Sandoval	54	.....	111	14,657	.....	.....
Santa Fe	27,013	2,030.44	23,941	1,703,091	.....	.....
Sierra	38	52.19	274	1,965	2,888	7,492
Socorro	33,162	23.61	56,941	1,416,098	2,031,297	.....
Torrance	188	.....	124	25,143	.....	.....
	219,078	16,882.78	552,373	10,461,812	4,466,781	14,224,798

a In order to avoid disclosing individual production, production of zinc from Grant, Luna, and Socorro counties is combined.

Ore sent to gold and silver mills and quantity of gold and silver contained in bullion produced in New Mexico in 1915.

Process.	Quantity.	Gold in bullion.	Silver in bullion.
	Short tons.	*Fine ounces.*	*Fine ounces.*
Amalgamation	11,143	16,391.76	2,956
Cyanidation	138,507	24,082.61	1,126,746
	149,650	40,474.37	1,129,702

Quicksilver and cyanide consumed in New Mexico in 1915, in pounds.

Quicksilver[1]	368
Potassium cyanide[2]	29,000
Sodium cyanide[2]	216,709

REDUCTION MILLS.

Mineral Resources for 1912, part 1, pages 832–835, contained a complete list of the reduction mills in New Mexico in 1912, with description of equipment and process. Changes in this list for 1915 have been noted in the text for the several counties, and reference should be made to the 1912 report for details of equipment.

REVIEW BY COUNTIES.[3]

BERNALILLO COUNTY.[4]

Assessment work only was done on the various prospects in the Coyote and Soda Springs districts, Bernalillo County, in 1915.

COLFAX COUNTY.[5]

Elizabethtown district (including Baldy).—The total value of the mine production of Colfax County increased from $69,858 in 1914 to $357,138 in 1915. Placer mines in this district yielded $2,631 in gold in 1915 as compared with $4,930 in 1914. The Aztec[6] and the Mystic mines were the only producing lode mines. A car of copper ore was shipped from the Mystic. A heavily increased yield was made from the Aztec mine and 10-stamp amalgamation-concentration mill. Small shipments of crude ore and concentrates carrying a high content in gold were also made from this property. The State Tax Commission of New Mexico[7] gives the output of this mine in 1915 as $343,951 gross and $291,191 net. The following table shows the production of Elizabethtown and Baldy districts (which is the output for Colfax County) from 1904 to 1915, inclusive:

Mine production in Elizabethtown district, Colfax County, N. Mex., 1904–1915.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Total value.
		Placer.	Deep.				
	Short tons.			*Fine oz.*	*Pounds.*	*Pounds.*	
1904	380	$90,639	$3,638	67	.....	.....	$94,316
1905	13	31,994	445	157	.....	.....	31,749
1906	.....	14,492	.....	93	.....	.....	14,554
1907	.....	11,914	.....	83	.....	.....	11,969
1908	.....	11,274	.....	66	.....	.....	11,309
1909	83	16,037	1,705	127	.....	.....	17,808
1910	93	9,588	3,433	261	.....	2,182	13,258
1911	2,306	9,860	31,547	1,254	5,587	.....	42,770
1912	3,025	8,385	27,316	634	6,243	.....	37,121
1913	3,222	4,550	15,588	254	1,147	134	20,475
1914	2,860	4,930	63,129	577	11,083	154	69,858
1915	2,673	2,631	350,745	2,483	14,092	787	357,138
Increase or decrease	− 187	−2,299	+287,616	+1,906	+ 3,009	+ 633	+287,280

[1] Represents 1 pound of quicksilver for every 44.54 ounces of gold.
[2] Represents 1 pound of cyanide for every 0.10 ounce of gold and 1 pound of cyanide for every 4.59 ounces of silver.
[3] Discussions of the geology of the several districts are given in the publications cited in many of the footnotes in this section
[4] Lindgren, Waldemar, The ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, pp. 162–163, 1910.
[5] Idem, pp. 18, 32, 36, 41, 51–54, 57–59, 60, 75, 91–108, 348.
[6] Lee, W. T., The Aztec gold mine, Baldy, N. Mex.: U. S. Geol. Survey Bull 620, pp. 325–330, 1916.
[7] Min. and Eng. World, Apr. 1, 1916, p. 656.

DONA ANA COUNTY.

Mine production in Dona Ana County, N. Mex., 1904–1915.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	zinc.	Total value.
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	5,580	.....	24,101	40,000	1,581,488	.....	$87,145
1905	6,566	$6,710	21,776	96,058	327,707	30,000	52,020
1906	16,220	.....	34,051	434,000	1,207,193	.....	175,386
1907	6,084	6	25,612	776,125	675,189	.....	207,920
1908	3,090	.....	9,283	21,150	379,697	.....	23,060
1909	2,816	248	16,975	10,600	772,023	.....	43,650
1910	2	.....	15	.....	705	.....	39
1911	5	.....	111	353	1,561	.....	173
1912	78	17	1,790	6,685	26,129	.....	3,397
1913	155	30	1,232	10,189	9,557	.....	2,774
1914	451	927	3,564	78,180	29,897	.....	14,462
1915	1,599	2,426	8,335	241,749	19,170	.....	49,859
Increase or decrease.	+1,148	+1,499	+4,771	+163,569	−10,727	.....	+35,397

Organ Mountains district.[1]—Lessees shipped a greatly increased quantity of lead and copper ores from the Excelsior and Bennett-Stephenson mines.

GRANT COUNTY.

Mine production in Grant County, N. Mex., 1904–1915.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Zinc.	Total value.
		Placer.	Deep.					
	Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	47,032	$8,081	$60,347	74,793	4,428,508	179,142	.....	$695,099
1905	81,160	10,943	35,064	86,629	5,291,222	321,035	257,203	954,026
1906	127,800	2,290	97,519	163,987	6,388,830	710,895	144,656	1,492,069
1907	146,746	3,782	109,260	224,279	8,046,315	1,394,390	73,729	1,948,582
1908	75,254	3,514	42,168	95,477	5,242,767	244,589	251,070	810,403
1909	89,576	3,584	34,242	74,198	5,176,585	215,070	203,278	769,590
1910	70,862	2,641	63,291	156,557	4,404,394	257,953	1,285,500	790,598
1911	93,770	4,043	112,241	221,882	3,918,928	694,247	306,895	772,481
1912	1,200,691	2,551	163,645	356,057	32,952,133	2,309,732	3,135,000	6,142,526
1913	1,984,304	1,646	102,971	206,215	53,436,177	446,805	2,553,322	8,674,423
1914	1,986,921	21,560	319,300	304,679	58,259,113	570,513	(*a*)	(*a*)
1915	2,523,275	1,979	363,104	508,552	72,487,200	2,251,383	(*a*)	(*a*)
Increase or decrease..	+536,354	−19,581	+43,804	+203,873	+14,228,087	+1,680,870	(*a*)	(*a*)

a To avoid disclosing individual production, the zinc production of Grant County is combined with that of Luna County.

Apache No. 2 (Anderson) district.[2]—A large quantity of silver-copper ore with calcite gangue was shipped from the Apache mine in this district.

Burro Mountain district.[3]—The Burro Mountain Copper Co. continued its installation of power plant, mine equipment, 1,000-ton

[1] Lindgren, Waldemar, op. cit., pp. 205–213.

[2] As distinguished from Apache (Chloride) district, Sierra County. See Hill, J. M., Mining districts of western United States: U. S. Geol. Survey Bull. 507, pp. 231, 240, 1912.
Lindgren, Waldemar, op. cit., pp. 343–344.
Weed, W. H., The copper mines of the United States in 1905: U. S. Geol. Survey Bull. 285, p. 118, 1906.

[3] Lindgren, Waldemar, op. cit., pp. 17, 19, 27, 28, 38, 61, 62, 321–324.
Paige, Sidney, Metalliferous ore deposits near the Burro Mountains, Grant County, N. Mex.: U. S. Geol. Survey Bull. 470, pp. 131–150, 1911.
Paige, Sidney, U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), 1916.
Weed, W. H., op. cit., p. 118.
Somers, R. E., Geology of the Burro Mountains: Am. Inst. Min. Eng. Bull. 101, pp. 957–996, May, 1915. Also Bush, F. V., Burro Mountain porphyry copper developments: Min. and Sci. Press, Feb. 6, 1915, pp. 222–224.

concentration mill, and other buildings in preparation for the operation of its large acreage in the Burro Mountains district. Lessees on this company's property shipped a considerable tonnage of copper ore, and the company shipped slag and concentrates from its experimental mill.

The annual report [1] of Phelps, Dodge & Co. for the calendar year 1915 says of the Burro Mountain Copper Co.:

> The first 500-ton section of the concentrator should be ready for service about March 1, 1916, and construction work designed to facilitate ore extraction in the mine was also about completed. The central power station of 2,000-horsepower capacity has been finished and tested. Two 1,000-horsepower Diesel engines are installed in this plant, and these are to be augmented in the future by a third of the same design, made by the Nordberg Manufacturing Co. The town-site at Tyrone, N. Mex., is rapidly assuming the appearance of a model town, with hospital and other semipublic buildings carefully grouped and planned under the direction of a New York architect, and about 21,000 feet of new roads were finished last year.
>
> Churn-drill prospecting was continued through 1915, carrying out the general scheme for testing the large northeastern group of mining claims by a series of holes placed at wide intervals. Three machines were in use, and 20 holes, having an average depth of 1,031 feet, were drilled. The general results of this work merely showed the far-reaching extent of the ore-bearing formations, but one hole was drilled through 67 feet of ore averaging 2.67 per cent copper. During the year 1,354,377 pounds of copper were produced from various sources, 524,200 pounds being credited to leasers.
>
> The test mill has been partly dismantled, as it has served its purpose in indicating the proper treatment in the 1,000-ton plant. A total of 11,008 tons of ore of various types was tested in this mill. In March the work of the mill was concluded, after testing a small unit of the Rork flotation machine, the results being practically the same as those obtained with the Towne machine under similar conditions. Shipments were made to Douglas of about 3,000 tons of slime tailings for the purpose of testing by leaching methods.
>
> As the policy of the company was to prepare the mine for ore extraction, extensive mine-repair work was necessary, and general development work was subordinated. The ore reserve, however, of December 31, 1915, was equivalent to 130,000,000 pounds of copper, contained in 2,555,000 tons of ore of 2.53 per cent grade. Duplicate steel headframes and hoisting engines have been installed at No. 2 and No. 3 shafts, and concrete shaft collars placed. The Niagara tunnel for ore transportation has been completed and a 350-ton ore bin constructed above the haulage road, to serve as storage and for loading the 30-ton cars that will be used. The tunnel is 8 feet 8 inches in width at the cap by 8 feet 10 inches clear height above the rail.

Lessees shipped copper ore from the Savannah Copper Co.'s properties. This property was purchased by the Burro Mountain Copper Co. in December, 1915.

Central district.[2]—The output of the Central district, embracing the towns of Bayard, Fierro,[3] Georgetown,[4] Hanover,[5] and Santa Rita,[5] was 2,395,795 tons, yielding $102,379 in gold, 73,267 ounces of silver, 66,581,366 pounds of copper, 1,542,234 pounds of lead, and an increased yield of zinc. This district ranks first in point of present production. Besides the Chino Copper Co.'s mines, at Santa Rita, there were 22 other producing mines in this district. Zinc carbonate ore was shipped from the Hanover mines, of the Empire Zinc Co., the Mountain Home group, Welsh group, and from other properties. Copper ore was shipped from the Copper Queen property at Fierro;

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[1] Min. and Sci. Press, Apr. 8, 1916, pp. 534–535.
Eng. and Min. Jour., Apr. 8, 1916, p. 651; also Eng. and Min. Jour. Apr. 22, 1916, p. 732.

[2] Lindgren, Waldemar, op. cit., pp. 57, 61, 317–318; Weed, W. H., op. cit., p. 118.
Paige, Sidney, U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), 1916.

[3] Lindgren, Waldemar, op. cit., pp. 47, 55, 296, 306, 312–313.

[4] Lindgren, Waldemar, op. cit., pp. 18, 30, 38, 62, 63–65, 306, 307, 318–319.

[5] Birkinbine, John, Iron ores of the United States: U. S. Geol. Survey Eighteenth Annual Rept., pt. 5, pp. 48–50, 1897.
Paige, Sidney, The Hanover iron-ore deposits, New Mexico: U. S. Geol. Survey Bull. 380, pp. 199–214, 1909.
Lindgren, Waldemar, op. cit., pp. 18, 38, 41–43, 51–53, 55, 57–58, 305, 317.
Weed, W. H., op. cit., p. 118.

copper-lead ore was shipped from the Ground Hog mine; and a large quantity of lead ore was shipped from the Lucky Bill mine, at Vanadium. A considerable quantity of lead and copper ores was shipped from other properties and various dumps in the district.

The Chino Copper Co. is mining a low-grade copper deposit at Santa Rita by steam shovels. The ore is concentrated at Hurley, where is located a 5-section wet-concentration-flotation mill. Concentrates are shipped principally to El Paso. The sixth annual report of the Chino Copper Co., dated April 1, 1916, covering the year ended December 31, 1915, says:

The gross production of copper in concentrates (158,444 tons) for the year was 68,293,893 pounds. After making smelter deductions the net production amounted to 64,887,788 pounds, or 95 per cent. In addition there were produced 3,991 ounces of gold, for which the company received $20 per ounce. This production of copper and gold resulted from the treatment during the year of 2,379,800 tons of ore. The unsold copper on hand at the end of the year 1915 was inventoried at 13.5 cents per pound.

The net operating profit amounted to $6,688,729.07; miscellaneous income received during the year from outside investments, rentals, etc., amounted to $229,073.63. The total income, therefore, amounted to $6,917,802.70. Deducting interest paid during the year, amounting to $3,818.83, leaves a net profit for the year applicable to dividends or for other capital purposes of $6,913,983.87 or $7.95 per share, as compared with $3.70 per share for the year 1914. Dividends paid during the year amounted to $3 per share, 50 cents per share for the first quarter, 75 cents per share each for the second and third quarters, and $1 per share for the fourth quarter, aggregating for the year $2,609,860; leaving surplus earnings for the year after the payment of dividends of $4,304,123.87. There was set aside for depreciation of plant and equipment an amount equaling 5 per cent of the total cost, this depreciation charge amounting to $257,265.26. This resulted in passing $4,046,858.61 to earned surplus account. The total dividends up to and including the dividends during the year 1915 aggregated $6,697,995. * * *

In June, 1915, churn drilling was resumed in a small way in order to determine the westerly limits of the Northwest ore body, so that the steam shovel at work in this section could carry the stripping out to the proper limits. Drilling was continued through the balance of the year in this and other sections, also in doing some other scouting work, which was necessary in advance of or in connection with stripping. The total drilling for the year was 6,909 feet. Since the beginning of operations there has been a total of 214,142 feet drilled.

Developments for the year resulted in an increase of positive and indicated ore fully equivalent to the quantity mined, leaving practically unchanged the ore reserve figures of the last annual report, viz, 90,000,000 tons of an average grade of 1.75 per cent copper. * * *

The total amount of ore and waste moved by steam shovels during the year was 4,480,025 cubic yards of material in place. Of this amount 3,133,916 cubic yards were stripping, the other remainder being equivalent to 2,600,271 tons of ore. Of the ore that was moved, 2,375,733 tons were shipped to the mill; the remainder, some of which was of low grade and all highly oxidized, was stored on the ore dumps or future treatment.

From the beginning of steam shovel operations on September 23, 1910, there has been moved a total of 17,494,441 cubic yards of material in place, of which 13,322,162 cubic yards were stripping, the remainder being equivalent to 8,370,627 tons of ore. Of this ore 944,833 tons have been stored in the stock piles at the mine. Of the remainder, 7,406,389 tons were shipped to the mill, the balance having been shipped direct to the smelter. * * *

During the first three months of the year operations were continued at part capacity, but in the latter part of April full time was resumed. Thus for the year 1915 there were only eight months of full operations.

For the first four months of the year there was an average of 4,812 tons of ore treated per day. For the last eight months of the year there was an average of 7,357 tons treated per day, an increase for the last eight months of over 53 per cent as compared with the first four months. For the 12 months the mill averaged 6,520 tons per day, or 1,304 tons per day for each of the five sections. The total amount of ore treated for the twelve months amounted to 2,379,800 tons, this being the largest amount of ore treated in a year since the beginning of operations. The average

running time while in commission of all sections for the year was 92.98 per cent of the possible time. The large increase in the amount of ore treated during the last eight months was made possible by the completion of the installation of additional power and by the changes made in the mill and in concentrating methods. The best previous record was for the first seven months of 1914, when an average of 1,345 tons per actual section day was made, while for the last eight months of 1915 the mill averaged 1,573 tons per section per day, or an increase in capacity equivalent to practically 17 per cent.

The average content of the ore treated for the year was 2.155 per cent copper. The total production of concentrates was 158,444 tons, corresponding to a ratio of concentration of 15.02 tons of ore to produce 1 ton of concentrates. The total amount of copper contained in concentrates was 68,293,893 pounds, corresponding to an average concentrate grade of 21.551 per cent copper and a recovery of 28.697 pounds of copper per ton of ore, representing an extraction of 66.588 per cent of the copper content. The ratio of concentration and the grade of concentrates were higher than for the previous year, as a result of the improvement in the concentrate recleaning plants which were in service throughout the year.

The average milling cost for the year was 54.19 cents per ton, a decrease of 0.82 cent from that of the previous year, and the lowest cost for any full running year since the plant started. This reduced cost resulted from the increased tonnage that it was possible to treat.

The production of copper contained in concentrates for the year by quarters was as follows:

	Pounds.
First quarter	11,732,508
Second quarter	18,455,502
Third quarter	18,545,638
Fourth quarter	19,560,245
Total	68,293,893

The average cost of net copper produced from concentrates, after making deductions for smelter allowances and crediting gold values, was 7.12 cents per pound, as compared with 7.6 cents per pound for the previous year. The gold credit amounted to 3.35 cents per ton of crude ore treated, or 0.12 cent per pound of copper produced. The per pound cost as stated includes operating expenses and charges of every nature except depreciation. If miscellaneous earnings for the year were credited to the cost of producing copper, the net cost of all copper, based as above stated, would be 6.75 cents per pound, as against 7.35 cents per pound on the same basis for the previous year.

Extensions and betterments in the mill and its operation are progressing satisfactorily. The improvements being applied will not only raise recoveries but will result in a very substantial increase in production.

Cost of additions and improvements to mill buildings, equipment, and water supply for the Hurley plant was $535,741.

Mine production in Central district, Grant County, N. Mex., 1904–1915.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	21,048	$5,582	282	3,264,208	11,977	.....	$430,607
1905	17,115	.....	.....	2,704,233	.....	.....	421,860
1906	39,155	4	1,524	3,075,001	235,070	99,656	614,648
1907	57,079	5,659	36,813	4,994,575	855,358	73,729	1,078,555
1908	41,852	777	296	3,994,502	29,122	251,070	541,231
1909	41,456	816	1,380	3,348,808	23,256	203,278	448,856
1910	37,008	.....	404	2,679,630	155	1,285,500	409,955
1911	45,584	104	8,673	1,413,189	605,978	290,122	325,156
1912	1,136,290	998	29,586	29,512,812	2,172,676	2,205,824	5,138,779
1913	1,948,471	9,697	12,500	51,695,656	331,440	2,187,266	8,167,144
1914	1,934,020	102,971	42,971	55,222,874	365,079	(a)	(a)
1915	2,395,795	102,379	73,267	66,581,366	1,542,234	(a)	(a)
Increase or decrease.	+461,775	−592	+30,296	+11,358,492	+177,155	(a)	(a)

a In order to avoid disclosing individual production, the production of zinc in Central district, Grant County, has been combined with that of Luna County.

Chloride Flat district (near Silver City).[1]—No production was made from this district in 1915.

Eureka district (Hachita, including Sylvanite).[2]—No ore was shipped from this district during 1915.

Fremont district.[3]—A car of copper ore was shipped from the Nutshell mine.

Gillespie, or Animas Mountains district.—No production was made in this district in 1915.

Gold Hill district.—A small production of gold was made from the Cline stamp mill.

Lordsburg district (including Pyramid and Virginia or Shakespeare districts.[4]—

Mine production in Lordsburg district, Grant County, N. Mex., 1904–1915.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
	Short tons.		*Fineounces.*	*Pounds.*	*Pounds.*	
1904	250	$1,184	2,580	18,200	12,000	$5,582
1905	366	10	7,584	48,000	.....	12,079
1906	1,743	5,168	27,261	212,601	.....	64,465
1907	5,645	8,761	31,303	463,335	10,522	122,646
1908	7,532	10,617	9,889	259,079	11,363	50,534
1909	10,690	25,983	50,154	589,969	8,862	129,140
1910	29,220	59,798	130,324	1,627,591	19,662	337,742
1911	46,139	106,648	182,448	2,455,336	2,157	510,359
1912	55,340	144,859	275,251	3,155,585	4,562	835,015
1913	31,284	55,234	154,779	1,601,461	14,572	397,588
1914	38,964	101,080	232,647	2,614,674	30,049	578,658
1915	92,093	222,848	374,325	3,890,365	28,723	1,094,795
Increase or decrease	+53,129	+121,768	+141,678	+1,275,691	−1,326	+516,137

The yield from this district was the largest in its history. All the ore was shipped to smelters. The average assay per ton for the district in 1915 was gold, 0.1171 ounce, silver 4.06 ounces, and copper 2.11 per cent. The principal producing mine was the Eighty-five. This company curtailed its production during the early part of 1915 on account of the unsettled condition of the copper market during that period, but during the later part of the year shipped the largest quantity of ore in its history. In October this company took over the property of the Atwood Mining Co. In addition to its mining operations, the company did a large amount of underground development and exploration work with core drills. Other producing mines were the Atwood, Battleship, Bonney, Carie, Dundee, Eldorado, Nellie Bly, Ontario, Robert E. Lee, Triangle, and Waldo-Bean.

Pinos Altos district.[5]—The production of gold in this district in 1915 decreased heavily. During 1914 a record production of gold had been made because of the uncovering of considerable high-grade

[1] Lindgren, Waldemar, op. cit., pp. 18, 26, 38, 63–65, 301–305, 1910.
Paige, Sidney, U. S. Geol. Survey Geol. Atlas, Silver City, folio (No. 199), 1916.
[2] Lindgren, Waldemar, op. cit., pp. 335–343.
[3] Darton, N. H., Geology and underground water of Luna County, N. Mex.: U. S. Geol. Survey Bull. 618, pp. 106–107, 1916.
Lindgren, Waldemar, op. cit., pp. 346–347, 1910.
[4] Graton, L. C., U. S. Geol. Survey Prof. Paper 68, pp. 332–335, 1910. Weed, W. H., op. cit., p. 118.
[5] Lindgren, Waldemar, op. cit., pp. 18, 35, 38, 43, 57–58, 59, 61, 62, 64, 75, 297–301.
Paige, Sidney, The ore deposits near Pinos Altos, N. Mex.: U. S. Geol. Survey Bull. 470, p. 109–125, 1911; U. S. Geol. Survey Geol. Atlas, Silver City folio (No. 199), 1916.

pockets of metallic gold. No new discoveries of this character were made in 1915, although some shipments of the output of 1914 were not made until early in the year 1915.

Placer gold in 1915 was credited with $1,979, and lode gold with $31,823. In 1914 placer and surface gold were credited with $21,650. Owing to the similarity of fineness of both placer and surface lode gold, it is probable that considerable lode gold was included in the placer classification in 1914. Placer operations in this district are desultory and confined to sluicing operations in the gulches after heavy rains.

Two new zinc concentration plants were erected in the district during 1915. The Pinos Altos Mining & Milling Co.'s 50-ton concentration plant with crusher, rolls, classifier, drier, and electrostatic separator, was under construction during 1914 and was completed and set in operation early in 1915 on zinc-lead ores from the Langston and Pacific mines. The lead is taken out on Wilfley tables. The zinc-copper-barium-manganese product from the Wilfley tables is dried and elevated to a series of screens. From the screens various sizes go to two Huff electrostatic machines. Two products are made by the Huff machines, a copper-iron concentrate and a zinc-barite concentrate. The latter goes to a wooden vat and is thoroughly wetted with a 0.5 per cent copper sulphate solution. In this solution a thin film of copper sulphide is precipitated on the zinc sulphide and makes the zinc particle a conductor of electricity. This concentrate is then again put through the drier, the screens, and the Huff machine, producing a high-grade zinc concentrate.[1] The Empire Zinc Co.'s Cleveland magnetic separation mill was completed and set in operation in November, 1915, and zinc concentrates were shipped during December and thereafter. The output of this mill promises a greatly increased production of zinc from the district in the future. Other producing mines were the Little Arizona, Manhattan, Silver Cell, and Silver Hill.

Mine production in Pinos Altos district, Grant County, N. Mex., 1904–1915.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Zinc.	Total value.
		Placer.	Deep.					
	Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	4,719	$7,750	$49,660	37,229	104,069	2,653	.....	$92,587
1905	6,348	10,943	31,442	39,585	103,469	.....	160,779	82,442
1906	14,074	2,290	89,674	83,566	328,788	.....	.....	211,409
1907	14,841	3,782	78,723	65,862	322,195	.....	.....	190,413
1908	1,451	1,479	8,548	8,941	34,514	3,953	.....	21,528
1909	38	3,584	2,083	1,377	6,200	418	.....	7,207
1910	20	2,494	1,372	223	269	2,226	.....	4,119
1911	355	4,043	1,406	5,616	3,232	4,063	16,773	9,968
1912	6,169	2,551	7,973	15,864	96,507	50,289	929,176	102,581
1913	3,643	1,646	29,162	28,276	100,555	83,067	366,056	87,626
1914	3,686	[a] 21,650	114,181	23,256	129,587	29,994	48,840	169,497
1915	7,024	1,979	31,823	19,856	377,463	130,638	(*b*)	(*b*)
Increase or decrease..	+3,338	−19,671	−82,358	−3,400	+247,876	+100,644	(*b*)	(*b*)

[a] Placer and surface lode mines combined. Only small quantity recovered by actual placer methods. Fineness so similar, separation not practicable.

[b] In order to avoid disclosing individual production, the production of zinc in Pinos Altos district, Grant County, has been combined with that of Luna County.

[1] Min. and Sci. Press, Jan. 29, 1916, p. 178.

San Simon (Granite Gap[1]*) district (Steins).*—A large quantity of silver-lead ore was shipped from the November mine.

Steeplerock district.[2]—In this district, long dormant, there was considerable work accomplished in unwatering and developing during the year, and 229 tons of ore carrying 195 ounces of gold and 10,600 ounces of silver was shipped from the Jim Crow mine. A shipment of lead ore was also made from the Delmire group. Toward the end of the year operations for unwatering the Carlisle group were commenced.

Steins Pass (Kimball[3]*) district.*—Considerable shipments of copper ore were made from the Johnny Bull mine and of lead ore from the Oldan.

Telegraph district (north of Lordsburg).—A small shipment of silver-lead ore was made from the Brock mine.

White Signal (Cow Springs) district (Whitewater).—Considerable copper ore was shipped from the Progressive mine, and one shipment of silver ore was made from the Rosena mine.

LINCOLN COUNTY.

Mine production in Lincoln County, N. Mex., 1904–1915.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Total value.
		Placer.	Deep.				
	Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	820	$20,100	$8,496	2,576	.....	2,261	$30,183
1905	3,060	2,260	5,215	757	14,404	7,511	10,532
1906	6,380	.....	16,463	1,946	.....	.....	17,767
1907	5,767	.....	41,417	721	.....	.....	41,893
1908	4,399	816	28,896	5,472	1,195	.....	32,770
1909	3,633	472	23,391	388	700	7,977	24,499
1910	10,727	1,400	53,876	559	189	5,614	55,849
1911	1,578	1,629	30,305	184	555	6,620	32,399
1912	2,003	1,008	21,408	1,005	9,988	103,911	29,358
1913	5,589	1,027	41,469	1,100	7,068	94,010	48,392
1914	13,540	908	62,499	961	15,068	10,641	66,360
1915	8,550	1,308	44,068	493	5,091	13,277	47,141
Increase or decrease	−4,990	+400	−18,431	−468	−9,977	+2,636	−19,219

Gallinas district.[4]—Several cars of copper-lead ore were shipped from this district.

Jicarilla district.[5]—Small placer mines in this district produced $1,308 in gold, as compared with $908 in 1914.

Nogal (Bonita, Parsons) district.[6]—During 1915 a 250-ton cyanidation plant was in the course of construction by the Parsons Mining Co. for the treatment of ore from the Hopeful, Parsons, and American mines. To operate this plant the company also installed 17 miles of high-tension electric transmission line.

Whiteoaks district.[7]—The Wild Cat Leasing Co. continued to produce bullion in the 20-stamp amalgamation mill on the North and South Homestake mines. Another lessee produced a small quantity of gold by the cyanidation of dump ore. In November, 1915, the Whiteoaks Mines Consolidated Co. acquired the Homestake mines

[1] Lindgren, Waldemar, op. cit., pp. 51, 53, 62, 63–64, 329–331, 340.
[2] Idem, pp. 68, 69–71, 327–328.
[3] Idem, pp. 68, 69–70, 328–329.
[4] Idem, p. 176.
[5] Idem, pp. 39, 51–53, 57–58, 59, 60, 75, 176, 183–184.
[6] Idem, pp. 30, 57–58, 75, 175–179.
[7] Idem, pp. 19, 39, 57–58, 60, 66, 175–176, 179–182.

and the Old Abe, Silver Cliff, Miners Cabin, and other properties in the district, and continued the operation of the Homestake mines throughout the remainder of the year. Considerable tungsten ore was also produced from the South Homestake lode.

LUNA COUNTY.

Mine production in Luna County, N. Mex., 1904–1915.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	1,576	$1,695	8,549	16,000	671,772	.....	$37,605
1905	1,346	.....	5,199	.....	463,956	225,000	38,221
1906	1,994	413	11,265	.....	831,193	103,836	61,673
1907	2,048	13,741	8,633	.....	1,022,773	.....	73,646
1908	288	3	1,077	5,934	127,535	.....	6,713
1909	1,163	3,208	6,916	1,115	682,906	.....	36,314
1910	525	26	2,484	47	298,112	.....	14,490
1911	229	104	1,278	1,814	98,888	.....	5,458
1912	3,090	5,687	24,265	.....	827,556	458,594	89,493
1913	5,185	11,085	41,664	1,453	1,158,682	702,028	126,771
1914	2,127	226	2,975	2,181	416,923	(a)	(a)
1915	2,082	491	2,795	4,080	148,766	(a)	(a)
Increase or decrease	−45	+265	−180	+1,899	−268,157	(a)	(a)

a In order not to disclose individual production, the production of zinc from Luna County in 1915 is included with that of Grant County.

Cooks Peak district.[1]—Lead carbonate and zinc carbonate and sulphide ores were shipped from this district. Producing mines were the Day-dream and Vision, Desdemona, Faywood, Monte Cristo, Othello, and Summit group.

Florida district.[2]—Zinc carbonate ore was shipped from the Mahoney property in the Florida Mountains.

Tres Hermanas district.[3]—Lead and zinc carbonate ores were shipped from this district in 1915.

Victorio (Gage) district.[4]—Several cars of silver-lead ore were shipped from the Rover mine.

OTERO COUNTY.

Mine production in Otero County, N. Mex., 1904–1915.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Total value.
		Placer.	Deep.				
	Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	170	$1,050	$1,569	164	14,400	.....	$4,586
1905	117	1,036	41	93	53,602	.....	9,495
1906	268	195	228	533	133,166	.....	26,481
1907	12,203	100	14,711	2,135	679,480	.....	152,116
1908	22,418	1,475	34,215	4,351	723,907	.....	133,552
1909	143	100	157	29	6,354	.....	1,098
1910	2,545	6,022	2,559	2,046	49,874	6,046	16,286
1911	1,096	.....	6,718	715	22,730	739	9,971
1912	3,792	2,034	11,005	1,107	146,588	.....	37,907
1913	25,582	42	49,830	7,088	760,914	1,911	172,179
1914	11,176	.....	38,515	5,761	418,316	2,027	97,416
1915	16 628	.....	54,979	6,255	872,748	.....	210,881
Increase or decrease	+5,452	.....	+16,464	+494	+454,432	−2,027	+113,465

[1] Lindgren, Waldemar, op. cit., pp. 37, 39, 62, 63, 64, 287–289.
Darton, N. H., Geology and underground water of Luna County, N. Mex.: U. S. Geol. Survey Bull. 618, pp. 102–103, 1916.

[2] Idem, pp. 27, 28, 30, 62, 225, 287, 289–290.
Darton, N. H., op. cit., pp. 107–108.

[3] Idem, pp. 38, 41, 51, 55, 57, 58, 287, 292–295; The Tres Hermanas mining district, N. Mex.: U. S. Geol. Survey Bull. 380, pp. 123–128, 1909.
Darton, N. H., op. cit., pp. 105–106.

[4] Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 68, pp. 18, 43, 62, 63, 64, 287, 290–292, 1910.
Darton, N. H., op. cit., pp. 103–104.

Highrolls (Sacramento) district.—Several cars of copper ore were shipped from the Courtney mine.

Jarilla (Orogrande, Silver Hill, Brice) district.[1]—Lode mines in the Jarilla district in 1915 produced 14,930 tons of ore yielding $54,974 in gold, 6,150 ounces of silver, and 853,257 pounds of copper, with a total value of $207,412, as compared with $93,010 in 1914. There was no yield of placer gold. Producing mines were the Alabama, By Chance, Delusion, Garnet, Mispah, Molly Gibson, Monte Carlo, and Nannie Baird. All the ore was shipped to smelters. In addition, considerable magnetite iron ore was shipped to the Colorado Fuel & Iron Co.'s steel mill, at Pueblo, Colo.

Tularosa district.[2]—A small lot of copper ore was shipped from the Hembrillo mine, and a few tons of ore were shipped from the Coyote mine. The Tularosa Copper Co. resumed work at its 100-ton concentration mill in October and during the rest of the year experimented with the testing of ores from the Virginia mine with the oil flotation process.

RIO ARRIBA COUNTY.

Bromide (Tusas) district.[3]—A small lot of silver-copper ore was shipped to the El Paso smelter from the Bromide mine, at Tres Piedras.

Hopewell (Headstone) district.[4]—No work was done on the placers of this district.

SANDOVAL COUNTY.

Cochiti (Bland) district.[5]—The Cossak Mining Co., which in September, 1914, built a 100-ton continuous counter-current decantation-cyanidation plant, operated it during the year 1915 until November 1, when the mill was shut down awaiting the installation of a new power house and the addition of new machinery.

SANTA FE COUNTY.

Mine production in Santa Fe County, N. Mex., 1904–1915.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Zinc.	Total value.
		Placer.	Deep.					
	Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	170	$4,135	$1,292	.....	2,308	.....	.....	$5,727
1905	180	4,002	2,241	42	.....	.....	.....	2,266
1906	128	6,737	7,143	53	.....	.....	.....	13,916
1907	21,338	1,231	16,748	17,635	1,231,260	.....	.....	275,870
1908	7	1,789	242	6	.....	.....	.....	2,034
1909	2,831	1,817	871	2,295	1,093	213,558	4,426	13,445
1910	4,739	4,262	3,877	3,359	5,150	262,023	74,759	26,173
1911	120	2,359	1,325	2,632	16,644	11,178	.....	7,663
1912	15,335	1,302	10,216	14,178	810,563	12,511	10,565	155,272
1913	29,800	129	26,746	22,076	1,798,769	794	.....	319,053
1914	23,584	1,312	9,040	5,723	293,360	52,948	89,860	59,182
1915	27,713	1,567	42,100	24,371	1,704,857	50,638	14,556	358,558
Increase or decrease	+4,129	+255	+33,060	+18,648	+1,411,497	−2,310	−75,304	+299,376

[1] Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 68, pp. 19, 35, 56, 60, 75, 184–187. Weed, W. H., op. cit., p. 118.
[2] Idem, pp. 77, 78, 184, 187–190.
[3] Idem, pp. 49, 50, 51, 124, 126, 130–133.
[4] Idem, pp. 27, 28, 49, 50–51, 75, 124–130.
[5] Idem, pp. 68, 69, 70, 71, 141, 150–158.

Cerrillos district.[1]—The 100-ton wet-concentration mill at the Tom Payne mine was operated intermittently from September 20 to the end of the year. The product was copper, lead, and zinc concentrates.

New Placers [2] *and San Pedro* [3] *districts.*—The mines and 125-ton matting plant of the Santa Fe Gold & Copper Co. were in operation continuously from May 24 throughout the year. The annual report of this company for 1915 says:

> [The] production [was] 3,376,246 pounds of matte, containing 1,747,090 pounds of copper, 24,570 ounces of sliver, and 2,104 ounces of gold. The total cost of producing refined copper was 10.6 cents per pound, after crediting the gold and silver to expense. The property was idle five months, and the remaining seven months' operations showed a profit of $141,430, not including depreciation, amounting to $50,000. Actual operation of the smelter started on May 24, and since then a considerable amount of exploration work has been done in the mine. Considerable work was done on the 300-foot level to find the "high-grade" ore body opened on the level above, but so far the ore developed has been lower in grade.[4]

There was a yield of $1,567 in placer gold from various small placers. Small shipments of ore were made from several other lode mines in the district.

SIERRA COUNTY.

Mine production in Sierra County, N. Mex., 1904–1915.

Year.	Ore.	Gold.		Silver.	Copper.	Lead.	Zinc.	Total value.
		Placer.	Deep.					
	Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	1,295	$22,979	$51,617	17,055	16,700	.....	.....	$86,632
1905	3,516	47,878	51,164	8,700	46,664	.....	.....	11,613
1906	3,246	1,509	16,539	8,102	5,995	.....	.....	24,633
1907	700	595	7,629	2,250	5,425	9,548	.....	11,300
1908	680	1,979	16,039	8,589	12,874	6,075	.....	24,524
1909	4,294	.....	10,450	25,698	25,838	49,023	.....	29,280
1910	8,306	584	11,113	15,778	2,448	11,274	.....	21,024
1911	5,036	823	26,962	16,487	5,374	28,088	.....	38,459
1912	252	1,546	2,597	11,236	8,988	21,001	.....	13,481
1913	269	423	434	2,529	2,568	32,685	.....	4,221
1914	98	442	1,305	3,982	14,436	5,743	.....	6,093
1915	438	1,757	1,079	316	2,228	24,617	7,492	5,472
Increase or decrease.	+340	+1,315	−226	−3,666	−12,208	+18,874	+7,492	−621

Caballos Mountains district.[5]—At the Gladys mine a considerable quantity of galena, vanadinite, and wulfenite ores were concentrated, and several cars of lead concentrates were shipped to El Paso. The lead concentrate contained the vanadinite. Several tons of molybdenum concentrates were produced, but not sold.

Chloride (Apache, Cuchillo Negro) district.[6]—No production was made in this district.

Hermosa district.[7]—A car of zinc ore was shipped from the Philadelphia mine.

[1] Clarke, F. W., and Diller, J. S., Turquoise from New Mexico: U. S. Geol. Survey Bull. 42, p. 39, 1887. Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 68, pp. 35, 36, 39, 57, 58, 60, 163–167, 1910.
[2] Lindgren, Waldemar, op. cit., pp. 17, 75, 76, 163, 164, 170–175.
[3] Idem, pp. 51–53, 55, 57–58, 60, 62, 64, 171–174.
[4] Eng. and Min. Jour., Mar. 11, 1916, p. 482. Min. and Sci. Press, Feb. 12, 1916, p. 253.
[5] Hess, F. L., Vanadium in the Sierra de los Caballos, N. Mex.: U. S. Geol. Survey Bull. 530, pp. 157–160, 1912.
[6] Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 68, pp. 27, 28, 29, 30, 74, 218, 229, 238, 283–285, 1910.
[7] Idem, pp. 18, 55, 62–67, 77, 218, 232, 233, 267–268.

Hillsboro (Las Animas) district.[1]—Several small lots of ore were shipped from lode mines in this district. Placer gold was recovered from the Luxemburg placer by the use of a Quenner trommel mill, and the dry concentrator of the Hilltscher Bros.[2] At the Andrews property, sinking of the new main working shaft was continued to 435 feet. It is proposed to move the antiquated mill to the new shaft and equip with new machinery.

Kingston (Black Range) district.[3]—No production was made in this district.

Tierra Blanca (Bromide No. 1) district.[4]—No production was made in this district.

SOCORRO COUNTY.

Mine production in Socorro County, N. Mex., 1911–1915.

Year.	Gold.		Silver.	
	Quantity.	Value.	Quantity.	Value.
	Fine ounces.		*Fine ounces.*	
1911	25,844.49	$534,253	1,109,945	$588,271
1912	25,427.30	525,629	1,126,439	692,754
1913	30,179.04	623,856	1,347,160	813,685
1914	30,542 38	631,367	1,424,763	787,893
1915	24,654.47	509,653	1,358,000	688,506
Decrease	5,887.91	121,714	66,763	99,387

Year.	Copper.		Lead.		Zinc.		Total. value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
1911	79,321	$9,915	2,124,901	$95,621	9,930,281	$566,026	$1,794,086
1912	89,776	14,813	2,193,178	98,693	9,962,478	687,411	2,019,300
1913	289,566	44,883	2,199,247	96,767	13,267,811	742,997	2,322,188
1914	214,722	28,588	674,795	26,317	13,785,176	703,044	2,177,179
1915	1,416,098	247,817	2,033,723	95,585	18,437,218	2,286,215	3,827,776
Increase	1,201,376	219,229	1,358,928	69,268	4,652,042	1,583,171	1,650,597

Cooney (Mogollon) district.[5]—This district continued to be the most important gold and silver producing district in New Mexico. The gold output represented 35 per cent of the State yield of this metal, and the silver 65 per cent of the total silver output.

The Cleaveland & Weatherhead mill was idle during the entire year, but the Fanney mill was operated continuously on ores from the Fanney, Johnson, Pacific, and other mines in the district, and the Last Chance mill was operated continuously on ore from its own property, no custom ore being handled during the year. At the Last Chance mine of the Mogollon Co., 2,768 feet of development work was done in 1915. An underground shaft was installed at the tunnel level.

[1] Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 68, pp. 18, 30, 31, 37, 39, 43, 62, 64, 65, 68, 69, 70, 75, 214, 218, 227–228, 238, 239, 272–276, 277. Weed, W. H., op. cit., p. 118.

[2] For discussion of dry placers in the United States see Heikes, V. C., and Yale, C. G., U. S. Geol. Survey Mineral Resources, 1912, pt. 1, pp. 255–262, 1913.

[3] Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 380, p. 274, 1909. Lindgren, Waldemar, U. S. Geol. Survey Prof. Paper 68, pp. 18, 31, 34, 37, 62, 65, 218, 224, 225, 226, 228, 232, 245, 268–270, 1910.

[4] Lindgren, Waldemar, op. cit., pp. 37, 64, 66, 218, 268–271.

[5] Idem, pp. 18, 42, 43, 44, 47, 68, 69–71, 191–204.

Mine production in Cooney or Mogollon district, Socorro County, N. Mex., 1904–1915.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1904	11,276	$61,880	79,014	422,308	.....	$162,484
1905	15,534	97,158	240,943	295,175	.....	288,735
1906	16,076	127,907	268,567	.....	.....	307,847
1907	20,698	105,413	418,338	150,000	.....	411,516
1908	19,546	116,418	278,939	.....	.....	264,256
1909	23,945	111,464	249,413	46	49	241,167
1910	50,514	304,210	595,669	.....	.....	625,871
1911	102,219	531,358	1,067,038	1,873	1,862	1,097,206
1912	101,361	524,858	1,093,158	184	386	1,197,197
1913	115,739	619,886	1,306,766	4,418	1,217	1,409,912
1914	136,124	629,102	1,410,327	.....	590	1,409,035
1915	119,710	509,165	1,301,059	.....	2,426	1,168,916
Increase or decrease	−16,414	−119,937	−109,268	.....	+1,836	−240,119

Magdalena (Kelly) district.[1]—The principal metal produced in this district is zinc, and for 1915 the yield of that metal increased from 13,785,176 pounds, valued at $703,044, to 18,437,218 pounds, valued at $2,286,215.

The 150-ton flotation (surface-tension, nonfroth) mill of the Ozark Smelting and Milling Co.[2] was operated continuously on zinc sulphide ore from the Graphic and Waldo mines, the product being zinc concentrate. In addition, copper sulphide, lead oxidized, zinc-lead oxidized, and zinc oxidized ores were shipped to smelters. Lead and zinc carbonate ores were shipped from the Ambrosia, Germany, Juanita, and Kelly mines. The magnetic separation and wet-concentration mill of the Empire Zinc Co. was not operated during the year.

Mine production in Magdalena district, Socorro County, N. Mex., 1904–1915.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1904	27,998	$154	5,024	3,200	688,209	17,991,780	$932,658
1905	30,411	.....	4,800	320,000	390,000	14,630,051	934,322
1906	35,478	.....	2,515	64,560	238,088	17,044,163	1,067,410
1907	3,630	13	4,406	24,045	707,981	676,356	85,158
1908	6,319	72	460	2,605	16,073	3,325,446	157,631
1909	30,724	435	17,925	170,792	3,085,279	12,878,241	860,051
1910	42,232	468	65,800	152,181	3,451,228	16,727,870	1,110,529
1911	25,840	352	42,773	77,448	2,123,039	9,930,281	694,266
1912	22,500	746	32,792	69,532	2,192,792	9,962,478	818,473
1913	47,647	3,942	40,212	278,252	2,198,030	13,267,811	911,069
1914	51,595	2,265	14,436	214,722	674,205	13,785,176	768,144
1915	75,401	488	56,897	1,406,789	2,031,297	18,437,218	2,657,209
Increase or decrease	+23,806	−1,777	+42,461	+1,192,067	+1,357,092	+4,652,042	+1,889,065

San Andreas Mountains (Hembrillo) district.[3]—Two cars of silver-copper ore were shipped from this district in 1915.

[1] Dutton, C. E., Mount Taylor and the Zuni Plateau: U. S. Geol. Survey Sixth Ann. Rept., p. 194, 1885. Lindgren, Waldemar, op. cit., pp. 18, 19, 47, 51–53, 55, 214, 218, 220, 241–258. Weed, W. H., op. cit., p. 118.
[2] For description see Min. and Sci. Press, Jan. 22, 1916, pp. 128–130.
[3] Lindgren, Waldemar, op. cit., pp. 35, 74, 205, 234.

TAOS COUNTY.

Red River district.[1]—A small quantity of ore from the Memphis mine was treated in the 3-ton cyanidation plant on the property. Development work was done on various other properties in the district.

Rio Hondo district.[2]—Efforts were begun toward the resumption of work on the Fraser group.

TORRANCE COUNTY.[3]

From several prospects north of Scholle and west of Mountainair, on the Atchison, Topeka & Santa Fe Railway, were shipped 188 tons of copper ore carrying 124 ounces of silver and 25,143 pounds of copper.

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[1] Lindgren, Waldemar, op. cit., pp. 35, 36, 42, 43, 68, 69, 70, 71, 82, 84–88.
[2] Idem, pp. 75, 83, 84.
[3] Idem, pp. 162–163.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN TEXAS.[1]

(MINES REPORT.)

By Charles W. Henderson.

PRODUCTION.

Silver has always been the principal metal produced in Texas, the output since 1885 being 12,417,882 ounces. The yield of silver in 1915 was 144,656 ounces greater than in 1914. The greater part continued to come from the Presidio silver mine and cyanidation mill, in the Shafter district, Presidio County. A small but increased quantity of ore carrying silver, copper, and lead was shipped from the Allamoore-Van Horn district, Culberson County; some gold, silver, lead, and zinc were produced in the Sierra Blanca district, El Paso County; and a small output of gold-silver bullion was made at Llano, Llano County.

Mine production of metals in Texas, 1885–1915.[a]

Period.	Gold.	Silver.		Copper.		Lead.		Zinc.		Total value (commercial).
		Quantity.	Commercial value.	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
		Fine oz.		*Pounds.*		*Pounds.*		*Pounds.*		
1885–1890	$6,906	1,670,720	$1,652,225	.....	.....	.....	.....	.....	.....	$1,659,131
1891–1900	30,682	4,332,214	2,979,288	42,000	$5,376	7,385	$318	.....	.....	3,015,664
1901–1910	3,372	3,950,644	2,266,537	35,383	4,647	295,018	13,611	95,957	$5,262	2,293,429
1911	21	424,394	224,929	.....	.....	122,800	5,526	.....	.....	230,476
1912	63	406,067	249,731	721	119	65,311	2,939	238,000	16,422	269,274
1913	340	427,553	258,242	34,665	5,373	225,227	9,910	652,607	36,546	310,411
1914	234	530,817	293,542	23,760	3,160	149,027	5,812	216,451	11,039	313,787
1915	1,503	675,473	342,465	42,491	7,436	219,298	10,307	30,395	3,769	365,480
	43,121	12,417,882	8,266,959	179,020	26,111	1,084,066	48,423	1,233,410	73,038	8,457,652
Increase or decrease, 1915	+1,269	+144,656	+48,923	+18,731	+4,276	+70,271	+4,495	−186,056	−7,270	+51,693

[a] For yearly output and authority for each, see U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 236, 1915.

REDUCTION MILLS.

Mineral Resources for 1912, part 1, page 879, contained a complete list of the reduction mills in Texas in 1912, with description of equipment and process. Any changes in this list for 1915 have been noted in the text for the several counties, and reference should be made to the 1912 report for details of equipment.

[1] For discussion of the geology of the districts mentioned in the following pages the reader is directed to the bibliography in Mineral Resources, 1912, pt. 1, pp. 876–877, 1913; to Survey Bulletin 507; The mining districts of the western United States, by J. M. Hill, with a geologic introduction by Waldemar Lindgren, 1912; and to Mineral Resources, 1908, pt. 1, pp. 539–540, 1909.

REVIEW BY COUNTIES.[1]

BREWSTER COUNTY.

Development work was done in the Alpine district. In this district is the Bird mine from which, in the past, some silver-bearing galena has been shipped to the El Paso smelter.[2]

BURNET COUNTY.[3]

There was a little prospecting and development work done in the district northwest of Burnet.

CULBERSON COUNTY.[4]

The mining districts of Culberson County were included in El Paso County before 1911. There was more activity in the Allamoore–Van Horn district than there has been for several years. From this district there was shipped 394 tons of ore containing 4,634 ounces of silver and 42,491 pounds of copper. Producing mines were the Allamoore, Hand of Fate, Hazel, Pacific, Texas, and several other properties. The Hazel mine, in pre-Cambrian sandstone,[5] has been an important producer of silver-copper ore.[6]

EL PASO COUNTY.

In the Sierra Blanca district several tons of silver-lead ore were shipped from the Flora Del mine, and a car of lead ore and a car of zinc ore were shipped from the Bonanza mine.

KNOX COUNTY.

The copper prospects near Truscott, in the blue clays of the Permian beds,[7] were abandoned in 1913, and no prospecting or development work was done in 1914 or 1915.

LLANO COUNTY.[8]

A small bar of gold bullion was shipped from the Heath mine[9] upon which property there is a 50-ton cyanidation plant.

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[1] In this section references to discussions of the geology of the several districts are given in the footnotes.

[2] Phillips, W. B., Lead ore in Burnet County, Tex.: Eng. and Min. Jour., vol. 77, p. 364, 1904.

[3] Phillips, W. B., op. cit., p. 364.

[4] Richardson, G. B., U. S. Geol. Survey Geol. Atlas, Van Horn folio (No. 194), 1913.

[5] Richardson, G. B., Reconnaissance of trans-Pecos Texas: Texas Univ. Mineral Survey Bull. 9, pp. 24–25, 1904.

[6] Von Streeruwitz, W. H., Report on the geology and mineral resources of trans-Pecos Texas: Texas Geol. Survey Second Ann. Rept., p. 699, 1891; Trans-Pecos Texas: Texas Geol. Survey Third Ann. Rept. pp. 387–389, 1892.

[7] Cummins, W. F., Notes on the geology of northwest Texas: Texas Geol. Survey Fourth Ann. Rept., pp. 232–238, 1893.
Phillips, W. B., Texas Geol. Survey Second Ann. Rept., p. 450, 1890.
Phillips, W. B., The Permian copper ores in Texas: Eng. and Min. Jour., Dec. 16, 1911, pp. 1181–1182.

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[9] McLaren, A., Gold and rare metal mining near Llano, Tex.: Salt Lake Min. Rev., vol. 14, No. 3, pp. 11–13, May 15, 1912. Paige, Sidney, U. S. Geol. Survey Bull. 450, pp. 70–72, 1911. Paige, Sidney, U. S. Geol. Survey Geol. Atlas, Llano-Burnet folio (No. 183), p. 13, 1912.

PRESIDIO COUNTY.

Shafter district.[1]—The greater part of the total silver output of Texas has come from the Shafter district and chiefly from the Presidio mine, which has been operated steadily since 1884. The ore, which is chiefly silver chloride (horn silver), with which are associated more or less isolated patches of silver-bearing galena, was treated from 1884 to 1913 by pan amalgamation; but in May, 1913, the mill was reconstructed into a 125-ton cyanidation plant, using the all-sliming process and continuous agitation and filtration. Operations were continuous in 1915. There were several cars of silver-lead ore shipped from the Last Chance mine.

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GOLD, SILVER, COPPER, LEAD, AND ZINC IN UTAH.

(MINES REPORT.)

By V. C. Heikes.

PRODUCTION.

Ore and a small quantity of bullion from Utah mines in 1915 contained gold, silver, copper, lead, and zinc valued at $55,105,070, an increase of $17,953,477, compared with 1914. There were 234 producers, including 5 placers, as against 204 lode producers and 7 placers in 1914. More than 59 per cent of the total value was for copper, an increase of $12,621,936 in 1915. Gold increased from $3,265,347 in 1914 to $3,609,109 in 1915, and silver increased from $6,168,669 to $6,242,795. The quantity and value of lead increased, its value being $9,398,470, or $2,716,868 greater than in 1914. The value of zinc (calculated as spelter) increased from $815,453 to $3,012,238 in 1915. The placer output of gold decreased from $1,231 in 1914 to $958 in 1915.

Mine production of metals.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	211	8,544,014	$3,265,347	11,154,916	152,034,002	171,323,137	15,989,267	$37,151,593
1915	234	10,451,445	3,609,109	12,313,205	187,671,188	199,967,437	24,292,240	55,105,070
Increase in 1915		1,907,431	343,762	1,158,289	35,637,186	28,644,300	8,302,973	17,953,477
1864–1915			86,189,230	339,288,357	1,475,213,038	3,595,588,124	141,095,210	[b]727,558,498

[a] Includes small placer production.
[b] The total, by years, to the end of 1913, appears in Mineral Resources, 1913, pt. 1, p. 366, 1914.

Since mining first began in the early sixties to the end of 1915, Utah mines have produced altogether an output of gold, silver, copper, lead, and zinc valued at $727,558,498. This includes $86,189,230 in gold, $251,961,520 in silver, $220,231,691 in copper, $159,460,143 in lead, and $9,715,914 in zinc. Dividends paid by 16 producers in 1915 amounted to the sum of $9,827,524. In the history of the State dividends paid to stockholders of mining property, representing about 85 mines, have amounted to $128,398,234 to the end of the year 1915.

ORE.

In 1915 there were 10,451,445 tons of ore sold or treated in Utah, containing recoverable metals valued at $55,105,070 (placer production included), an increase of 1,907,431 tons, compared with the production of 1914. The average total value per ton was $5.27 in 1915, against $4.35 in 1914, and the gold and silver value per ton decreased from $1.10 to 94 cents. In addition to the large output of low-grade "porphyry" copper ore, considerable old mine dump material continued to be shipped to the smelters from the Tintic district.

The output of dry or siliceous ores decreased from 149,902 tons in 1914 to 61,976 tons in 1915. This classification includes 13,883 tons of low-grade siliceous gold ores, averaging $4.80 in gold and 0.76 ounce of silver per ton. Gold and silver mixed ores, dry or siliceous in character, aggregated 11,135 tons and averaged per ton $2.84 in gold, 10.29 ounces of silver, 22.83 pounds of copper, and a trace of lead. The siliceous silver ores mined in 1915 by 18 producers amounted to 36,958 tons and averaged per ton $2.51 in gold, 24.64 ounces of silver, 11.66 pounds of copper, and 27.40 pounds of lead, against 69,379 tons produced by 20 producers in 1914, which averaged $1.64 in gold, 11.47 ounces of silver, 3.21 pounds of copper, and 11.01 pounds of lead. The Iron Blossom mine, in the Tintic district, was the largest producer of silver ore, the district taking the lead in 1915, with 9 producers. At the Ontario mine, situated at Park City, the production of silver ore was not so large as in 1914. Only a few tons of iron manganese ore were shipped, against 883 tons in 1914. This ore came in 1915 from one mine in Beaver County.

The copper ore mined by 62 producers amounted to 9,436,450 tons and contained 22 cents in gold and 0.22 ounce of silver per ton and 0.94 per cent of copper, and averaged $3.63 a ton in value. Comparison with ore of similar character produced in 1914 shows that the gold and silver content decreased slightly and that the copper content was exactly the same. Of the copper ore mined, the larger part, or 8,908,567 tons, was from the low-grade "porphyry" deposits. This ore produced 421,645 tons of copper concentrates, which were smelted. There were 509,762 tons of copper ore smelted directly, of which 368,599 tons were sulphide ore, assaying $2.01 in gold and 1.98 ounces of silver per ton, and 1.52 per cent of copper, and valued in all per ton at $10.39; and 141,163 tons were oxidized ore, assaying $4.05 in gold and 6.64 ounces of silver per ton, and 2.10 per cent of copper, valued in all per ton at $14.79.

There was very little change in the quantity of lead ore mined compared with that of 1914. In 1915 the output of 143 producers aggregated 528,009 tons and averaged $1.78 in gold and 14.7 ounces of silver per ton, 0.68 per cent of copper and 14.38 per cent of lead, and $25.11 in total value per ton. Of this output, 378,352 tons of sulphide and oxidized ores in about equal quantities were shipped directly to the smelters, the total quantity averaging $2.30 in gold and 18.53 ounces of silver per ton, 0.71 per cent of copper and 17.6 per cent of lead, and $30.72 in value per ton. Of the lead ores, 134,060 tons were concentrated, yielding 50,438 tons of lead concentrate averaging 0.055 ounce of gold and 13.59 ounces of silver per ton, and 1.47 per cent of copper and 16.78 per cent of lead, and

$28.96 in total value per ton. From the lead-zinc ores milled, 327,727 tons produced 98,820 tons of lead concentrate averaging 0.18 ounce of gold and 12.16 ounces of silver per ton, and 0.84 per cent of copper, 22.81 per cent of lead, and $34.34 in total value per ton. The zinc concentrates saved from the lead-zinc ore milled aggregated 18,675 tons and averaged 0.008 ounce of gold and 8.44 ounces of silver per ton, 0.03 per cent of copper, 2.21 per cent of lead, and 38.47 per cent of zinc (spelter).

Zinc ore and old tailings shipped or milled from 34 properties in 1915 aggregated 34,320 tons, against 4,670 tons from 14 producers in 1914. Of this quantity, 17,210 tons was ore of smelting grade and 17,110 tons was old tailings re-treated, which yielded 912 tons of zinc concentrates, averaging 0.03 ounce of gold and 7.47 ounces of silver per ton, 1.92 per cent of lead and 25.52 per cent of zinc, and $69.60 in value per ton. The 17,210 tons of ore of smelting grade averaged 27.45 per cent of zinc (spelter) with some gold, silver, copper, and lead. Of the ore shipped directly to smelters, 15,087 tons were oxidized or mixed carbonate and silicate zinc ores, averaging 27.17 per cent zinc (spelter), and 2,123 tons were sulphide ore averaging 29.48 per cent zinc (spelter).

Copper-lead ore, most of it oxidized or carbonates, increased from 1,183 tons produced by 20 operators in 1914 to 5,329 tons produced by 10 mines in 1915. Of this ore 5,216 tons was of smelting grade and averaged 25 cents in gold and 13.58 ounces of silver per ton, 3.35 per cent of copper and 8.68 per cent of lead, and $27.03 in value per ton.

Concentrates of all kinds produced in Utah in 1915, including those heretofore mentioned, aggregated 596,363 tons, contained nearly 34 per cent of the gold against about 33 per cent in 1914; 20 per cent of the silver against nearly 19 per cent in 1914; 85 per cent of the copper against 84 per cent; more than 31 per cent of the lead against 32 per cent; and more than 61 per cent of the zinc against about 55 per cent in 1914. In 1915 the recoverable metal content of the concentrates was valued at $35,193,022, or a total average value per ton of $59.01, as against a total value in 1914 of $21,922,428, or a total average value per ton of $43.80.

Crude ore of all kinds shipped directly to the smelters represented over 9 per cent of the total output and produced 65 per cent of the gold in 1915 as against nearly 67 per cent in 1914; 79 per cent of the silver against 78 per cent; nearly 15 per cent of the copper against a little over 15 per cent; 67.7 per cent of the lead against 67.4 per cent; and 39 per cent of the zinc against more than 44 per cent in 1914. In 1915 the total value of the crude ore shipped to smelters was $19,721,027, or an average value per ton of $20.58, as against a total value in 1914 of $15,004,591, or an average value per ton of $16.48.

At mills using cyanidation and amalgamation 0.79 per cent of the total gold and 0.05 per cent of the silver was recovered from 2,167 tons of ore and 11,296 tons of old tailings. The value of the gold and silver recovered from ore and tailings was $32,003, or $2.37 a ton. In 1914 the recovery of gold and silver from ores given similar treatment was valued at $21,706, or an average value per ton of $1.23.

Ore and metals produced in Utah in 1915.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	6	.....	$958	4	.....	.....	.....
Dry or siliceous	36	61,976	191,187	1,035,712	687,998	1,015,806	.....
Copper	62	9,436,450	2,092,979	2,065,661	177,784,460	20,401	.....
Lead	143	528,009	941,423	7,759,842	7,135,528	151,803,997	.....
Zinc	34	34,320	679	17,633	1,250	307,737	9,915,334
Copper-lead	10	5,329	1,362	71,497	354,162	911,594	.....
Lead-zinc	18	385,361	380,521	1,362,856	1,707,790	45,907,902	14,376,906
	.....	10,451,445	3,609,109	12,313,205	187,671,188	199,967,437	24,292,240

Ore sold or treated in Utah in 1915, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaver	200	18,658	19,725	2,452	.....	12,779	53,814
Boxelder	.....	2,092	134	4,788	.....	.....	7,014
Cache	.....	1	.....	40	.....	.....	41
Emery	10	.....	.....	139	.....	.....	149
Garfield	.....	1	.....	.....	.....	.....	1
Grand	.....	2	.....	.....	.....	.....	2
Iron	867	.....	.....	.....	.....	.....	867
Juab	56,113	113,263	111,031	4,297	79	.....	284,783
Millard	39	.....	.....	.....	.....	.....	39
Morgan	.....	.....	108	.....	.....	.....	108
Piute	178	8	6	.....	.....	.....	192
Salt Lake	611	9,302,117	205,289	437	204	209,344	9,718,002
Summit	3,750	.....	73,394	17,110	.....	99,300	193,554
Tooele	15	188	104,639	2,003	5,046	.....	111,891
Uinta	.....	6	.....	.....	.....	.....	6
Utah	20	2	7,855	3,054	.....	3	10,934
Wasatch	.....	25	5,828	.....	.....	63,935	69,788
Washington	173	65	.....	.....	.....	.....	238
Weber	.....	22	.....	.....	.....	.....	22
	[a] 61,976	9,436,450	528,009	34,320	5,329	385,361	10,451,445
Value per ton in gold and silver.	$11.56	$0.33	$9.23	$0.28	$7.06	$2.78	$0.94

[a] Includes 13,883 tons of gold ore, 11,135 tons of gold and silver ore, and 36,958 tons of silver ore.

GOLD.

The mine production of gold reported from Utah in 1915 was valued at $3,609,109, an increase of $343,762, compared with 1914. The largest part of the gold was contained in ores produced in Salt Lake County and amounted to $2,516,844, against $2,159,500 in 1914. Juab County ranked next with $910,354, against $933,072 in 1914. Bingham district produced $2,507,477 and Tintic district $916,775; in 1914 these productions were, respectively, $2,151,520 and $953,790. Tooele County mines were credited with $15,433, against $16,468 in 1914. Placer gold was produced in Garfield, San Juan, and Uinta counties and amounted in value to $958, against $1,231 in 1914. Ores treated in mills equipped for amalgamation produced $19,551 in gold in 1915 from 1,399 tons of ore mined in Beaver, Juab, and Washington counties. Cyanidation was carried on in Beaver, Iron, and Juab counties and produced $9,160 in gold from 768 tons of ore and 11,296 tons of old tailings. The gold extracted by amalgamation averaged $13.97 a ton of ore treated, as against $3.97 a ton treated in 1914; and by cyanidation $0.76, as against $0.71. Concentrates of copper, lead, zinc, and a small

quantity of siliceous concentrate contained $1,220,041 in gold, against $1,069,662 in 1914. Copper concentrates contained the largest quantity of gold, or 37,836.33 ounces, against 35,863.89 ounces in 1914 and 29,699.38 ounces in 1913; the lead concentrates contained 20,952.08 ounces, against 15,739.60 ounces in 1914; and the zinc concentrates 197.06 ounces, against 74.39 ounces in 1914.

Mine production of gold in Utah in 1915, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaver		160.40	29.28	164.13			276.42	630.23
Garfield	28.15							28.15
Grand			.48					.48
Iron		160.36						160.36
Juab		6,467.26	26,753.18	10,815.04	0.83	2.07		44,038.38
Millard		44.41						44.41
Piute		1,616.57		.95				1,617.52
Salt Lake		116.21	74,458.26	29,794.64		4.12	17,379.10	121,752.33
San Juan	6.00							6.00
Summit		73.69		3,149.57	32.02		309.04	3,564.32
Tooele		1.08	5.94	679.85		59.70		746.57
Uinta	12.19							12.19
Utah		9.89	.04	737.61				747.54
Wasatch			.65	199.55			443.14	643.34
Washington		598.80	.03					598.83
	46.34	*a* 9,248.67	101,247.86	45,541.34	32.85	65.89	18,407.70	174,590.65

a Includes 3,226.24 ounces from gold ore, 1,534.16 ounces from gold and silver ore, and 4,488.27 ounces from silver ore.

SILVER.

The mine production of silver in Utah in 1915, including a small placer output, was 12,313,205 ounces, valued at $6,242,795, an increase of 1,158,289 ounces in quantity and $74,126 in value. The largest production was from Juab County, credited with 4,005,600 ounces, against 4,444,996 ounces in 1914. Salt Lake County had the next largest output, 3,152,267 ounces in 1915, against 2,629,153 ounces in 1914. The Bingham district in Salt Lake County produced 2,507,477 ounces, or nearly eight-tenths of the county total; Tintic district, in Juab and Utah counties, 4,370,984 ounces; and the Park City region, in Summit and Wasatch counties, 3,754,598 ounces. Concentrates produced at milling plants yielded 2,464,903 ounces of silver, against 2,114,993 ounces in 1914. The copper ores milled produced 412,745 ounces, against 358,486 ounces in 1914 and 324,586 ounces in 1913. Lead concentrates from low-grade lead ore contained 1,887,105 ounces of silver, or an average per ton of 12.64 ounces, against 1,695,790 ounces, or an average of 13.25 ounces, in 1914; zinc concentrates contained 8.40 ounces per ton, against 4.97 ounces per ton in 1914. The silver content of bullion produced from ores and tailings treated by amalgamation was 496 ounces, against 78 ounces in 1914, and that produced by cyanidation was 5,998 ounces, against 11,536 ounces in 1914. At Park City experiments were made on the American Flag ores with a leaching process, for which the Grasselli mill was purchased and remodeled. Results were not favorable and only a few tons of silver precipitates containing copper and lead were shipped. The Tintic Milling Co. reconstructed the Knight-Christensen mill in the Tintic district and will ship precipi-

tates in 1916. This company uses the same leaching process which was successful on Ontario ores at Park City.

Mine production of silver in Utah in 1915, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaver	.....	1,017	5,409	181,055	6,020	.....	86,193	279,694
Boxelder	.....	.....	.....	47	.....	.....	.....	47
Emery	.....	125	.....	.....	.....	.....	.....	125
Garfield	2	.....	11	.....	.....	.....	.....	13
Grand	.....	.....	50	.....	.....	.....	.....	50
Iron	.....	5,620	.....	.....	.....	.....	.....	5,620
Juab	.....	932,232	853,101	2,213,310	4,798	2,159	.....	4,005,600
Millard	.....	82	.....	.....	.....	.....	.....	82
Morgan	.....	.....	.....	424	.....	.....	.....	424
Piute	.....	2,607	.....	168	.....	.....	.....	2,775
Salt Lake	.....	6,423	1,205,445	1,384,481	.....	5,454	550,464	3,152,267
San Juan	2	.....	.....	.....	.....	.....	.....	2
Summit	.....	86,147	.....	2,758,025	6,815	.....	257,341	3,108,328
Tooele	.....	927	1,158	666,114	.....	63,884	.....	732,083
Uinta	.....	.....	27	.....	.....	.....	.....	27
Utah	.....	310	33	378,783	.....	.....	50	379,176
Wasatch	.....	.....	27	177,435	.....	.....	468,808	646,270
Washington	.....	222	378	.....	.....	.....	.....	600
Weber	.....	.....	22	.....	.....	.....	.....	22
	4	[a] 1,035,712	2,065,661	7,759,842	17,633	71,497	1,362,856	12,313,205

[a] Includes 10,613 ounces from gold ore, 114,580 ounces from gold and silver ore, 910,519 ounces from silver ore.

COPPER.

In 1915 the mine production of copper in Utah was 187,671,188 pounds, valued at $32,842,458, an increase of 35,637,186 pounds in quantity and of $12,621,936 in value. Bingham or West Mountain district produced 176,593,414 pounds of copper in 1915, against 141,924,811 pounds in 1914, 144,920,494 pounds in 1913, 116,621,793 pounds in 1912, and 129,995,865 pounds in 1911; Tintic district produced 5,357,932 pounds in 1915, against 5,290,471 pounds in 1914; Park City region produced 2,287,172 pounds, against 1,559,953 pounds in 1914; Beaver County, 428,916 pounds, against 1,511,888 pounds in 1914; and Tooele County, 2,257,204 pounds, against 1,295,288 pounds in 1914.

Concentrates of all kinds produced at Utah milling plants contained 159,593,666 pounds of copper, against 128,339,987 pounds in 1914. Copper concentrates contained 156,436,723 pounds, against 125,778,515 pounds in 1914; lead concentrates, 3,142,093 pounds, against 2,558,128 pounds in 1914; and zinc concentrates, 12,787 pounds, against 3,344 pounds in 1914. Crude ore shipped to smelters contained 27,885,899 pounds of copper, against 23,626,771 pounds in 1914. The crude copper ores smelted contained 21,478,606 pounds, of which 15,536,616 pounds were from sulphide ores and 5,941,990 pounds were from oxidized ores. Lead ores smelted produced 5,369,670 pounds of copper, the sulphide ores yielding 3,548,833 pounds and the oxidized ores 1,820,837 pounds. Copper-lead ores, all of which were oxidized, contained 349,692 pounds of copper. The dry or siliceous ores, used principally for fluxing at smelting plants, contained 686,681 pounds, against 1,972,888 pounds in 1914. Copper ore from the low-grade copper-bearing porphyries contained 156,040,257 pounds of copper, against 125,777,441 pounds in 1914, 126,364,491 pounds in 1913, and 102,662,335 pounds in 1912.

Mine production of copper in Utah in 1915, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaver	33	334,161	75,220	.....	.....	19,502	428,916
Boxelder	.....	328,630	.....	.....	.....	.....	328,630
Cache	.....	102	.....	.....	.....	.....	102
Emery	166	.....	.....	.....	.....	.....	166
Garfield	.....	750	.....	.....	.....	.....	750
Grand	.....	428	.....	.....	.....	.....	428
Juab	667,151	4,433,357	262,888	1,250	6,888	.....	5,371,534
Millard	968	.....	.....	.....	.....	.....	968
Morgan	.....	.....	228	.....	.....	.....	228
Piute	351	882	112	.....	.....	.....	1,345
Salt Lake	15,570	172,585,145	2,999,039	.....	22,272	1,314,008	176,936,034
Summit	3,659	.....	1,689,843	.....	.....	118,758	1,812,260
Tooele	68	55,499	1,876,635	.....	325,002	.....	2,257,204
Uinta	.....	5,724	.....	.....	.....	.....	5,724
Utah	32	381	14,063	.....	.....	.....	14,476
Wasatch	.....	1,890	217,500	.....	.....	255,522	474,912
Washington	.....	35,568	.....	.....	.....	.....	35,568
Weber	.....	1,943	.....	.....	.....	.....	1,943
	[a] 687,998	177,784,460	7,135,528	1,250	354,162	1,707,790	187,671,188

[a] Includes 2,648 pounds from gold ore, 254,211 pounds from gold and silver ore, and 431,139 pounds from silver ore.

LEAD.

The mine production of lead in Utah in 1915 was 199,967,437 pounds, exceeding the output of any previous year, and was 28,644,300 pounds more than the output in 1914. Bingham or West Mountain district, with 80,004,006 pounds, had the largest production in 1915, against 76,453,128 pounds in 1914, 71,001,138 pounds in 1913, and 43,822,495 pounds in 1912. The greatest part of the production at Bingham came from the Highland Boy, Utah Apex, Bingham New Haven, Utah Metal & Tunnel Co., Brooklyn, and Dalton & Lark mines. Park City region produced 49,350,377 pounds of lead, against 32,323,066 pounds in 1914. Tintic district produced 32,657,018 pounds, against 36,510,911 pounds in 1914. The combined production of the Ophir and Rush Valley districts, in Tooele County, aggregated 16,383,700 pounds, against 12,611,432 pounds in 1914. The output in Beaver County decreased from 9,337,928 pounds in 1914 to 8,589,416 pounds in 1915. Lead contained in concentrate recovered at milling plants and shipped to smelters amounted to 62,868,183 pounds, against 55,404,883 pounds in 1914. The lead concentrates averaged 20.77 per cent of lead in 1915 and 21.55 per cent in 1914; zinc concentrates contained 859,580 pounds, averaging 2.19 per cent of lead in 1915 and 1.10 per cent in 1914. The total crude ore of shipping grade contained 135,391,781 pounds, against 115,424,056 pounds in 1914. Sulphide lead ore contained 64,717,208 pounds of lead, against 59,671,375 pounds in 1914. The oxidized lead ores carried 68,462,869 pounds, against 53,773,366 pounds in 1914. Zinc-lead ores shipped directly to smelters contained 2,616 pounds in 1915, against 1,060,762 pounds in 1914. Of the zinc ores shipped in 1915 the oxidized ores contained 62,280 pounds of lead and the sulphide ores 210,457 pounds. Copper-lead ores, all of which were oxidized or carbonate ores, contained 905,896 pounds of lead.

Mine production of lead in Utah in 1915, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaver	2,122	.....	5,532,492	210,457	.....	2,844,345	8,589,416
Boxelder	.....	.....	38,458	.....	.....	.....	38,458
Emery	262	.....	.....	.....	.....	.....	262
Juab	907,225	19,457	28,400,094	62,280	17,556	.....	29,406,612
Morgan	.....	.....	48,501	.....	.....	.....	48,501
Piute	.....	.....	3,231	.....	.....	.....	3,231
Salt Lake	16,643	944	62,837,901	.....	28,629	29,426,529	92,310,646
Summit	88,276	.....	33,525,777	35,000	.....	4,742,060	38,391,113
Tooele	324	.....	15,739,221	.....	865,409	.....	16,604,954
Utah	954	.....	3,613,132	.....	.....	894	3,614,980
Wasatch	.....	.....	2,065,190	.....	.....	8,894,074	10,959,264
	[a] 1,015,806	20,401	151,803,997	307,737	911,594	45,907,902	199,967,437

[a] Includes 953 pounds from gold ore, 2,305 pounds from gold and silver ore, and 1,012,548 pounds from silver ore.

ZINC.

The advance in price of zinc brought out zinc ore and concentrates from many sources. The new producing districts were Promontory in Box Elder County, Hyrum in Cache County, and Woodside in Emery County. Zinc production continued from Tintic, Park City, Ophir, Stockton, and Bingham districts. In all, the mine production of zinc (calculated as spelter) in Utah in 1915 was 24,292,240 pounds, valued at $3,012,238, against 15,989,267 pounds, valued at $815,453 in 1914. Park City region led in output, its mines yielding 7,771,350 pounds of zinc (spelter), compared with 3,173,313 pounds in 1914. Most of the production was from the Daly-Judge property and important quantities were derived from the treatment of the old tailings on the flats below the town. Salt Lake County, with Bingham the principal source, produced 5,721,022 pounds of zinc (spelter), against 4,121,977 pounds in 1914. Beaver County decreased in output from 7,143,746 pounds in 1914 to 2,989,811 pounds in 1915. The new zinc discovery in the Promontory district of Boxelder County yielded 2,482,578 pounds of zinc in 1915. Tintic district increased in output from 758,217 pounds in 1914 to 3,845,058 pounds in 1915.

Lead-zinc ores, of which 327,727 tons were concentrated, produced 18,675 tons of zinc concentrate containing 14,369,838 pounds of zinc, against 8,869,280 pounds in 1914. In addition to this output of milled product, 17,110 tons (estimated) of old tailing produced 912 tons of concentrate, yielding 465,466 pounds of zinc (spelter). Crude ore smelted contained 9,456,936 pounds of zinc, of which 9,449,868 pounds were derived from zinc ores and 7,068 pounds from lead-zinc ores. In 1915 the oxidized zinc and lead-zinc ores predominated and produced, respectively, 8,198,280 pounds and 7,068 pounds of zinc. The sulphide zinc ores yielded 1,251,588 pounds of zinc (spelter).

Mine production of zinc (spelter) in Utah in 1915, in dry pounds.

County.	Zinc ore.	Lead-zinc ore.	Total.
Beaver	1,417,216	1,572,595	2,989,811
Boxelder	2,482,578	.....	2,482,578
Cache	16,895	.....	16,895
Emery	59,075	.....	59,075
Juab	2,356,086	.....	2,356,086
Salt Lake	224,645	5,496,377	5,721,022
Summit	465,466	1,893,840	2,359,306
Tooele	1,198,172	.....	1,198,172
Utah	1,695,201	2,050	1,697,251
Wasatch	.....	5,412,044	5,412,044
	9,915,334	14,376,906	24,292,240

Zinc ore and concentrates produced from Utah mines and mills sold in 1915.

County.	Classification.	Quantity.	Average assay of ore or concentrates.[a]
		Short tons (dry weight).	*Per cent of zinc.*
Beaver	Sulphide ore	2,123	35.29
Beaver, Boxelder, Cache, Emery, Juab, Salt Lake, Tooele, and Utah.	Mixed carbonate and siliceous ore.	10,804	44.35
Beaver, Salt Lake, Summit, and Wasatch	Concentrates	19,587	44.55
	Ore and concentrates	32,514	43.99

[a] Actual zinc content.

METAL-MINING INDUSTRY.

In August, 1914, copper producers curtailed their output, but at the beginning of 1915 conditions gradually began to improve, and in March the industry was in full swing for a record year. The production of metals in Utah was greatly increased over that of 1914. There were no labor troubles of note; the trouble at Park City lasted only 14 days. Labor was plentiful, and in the copper camps wages were increased with the increase in the price of the metal.

An extension of the railroad from Wasatch to Alta, in Little Cottonwood Canyon, was begun and grading to its terminal was nearly completed. It is to be narrow gage and is said to be financed by strong interests. Hauling of the ores down the Big Cottonwood Canyon from the Maxfield and Cardiff mines was continued by wagon, but the use of motor trucks is contemplated before another year is ended. No important mineral discoveries were made, but some rich ore deposits were opened at Bingham in the Utah Metal property, at Promontory in Boxelder County, and at Alta in Salt Lake County. The strike of gold ore in the Bull Valley region, though important, did not yield steadily.

METALLURGIC INDUSTRY.

GENERAL STATEMENT.

Very little gold or silver was recovered either by amalgamation or by cyanidation. Amalgamation was in use in mills situated in Beaver, Juab, and Washington counties. Cyanidation of ores was carried on at the Sheep Rock mill in Beaver County and at the May Day

waste dump in Tintic district, and some bullion came from the clean up of a cyanide mill in Iron County. Of the 26 milling plants operated in 1915 in Utah, 3 were amalgamation plants, 1 was equipped for both concentration and cyanidation, 2 were using cyanidation only, and 20 were straight concentration plants, of which 7 were equipped with the oil flotation process. Only one chloridizing-roasting plant operated in 1915 on silver ore from the American Flag mine at Park City; some silver precipitates were shipped, but the process was not entirely satisfactory.

Experiments at Silver City in the Knight-Christensen mill continued until it was destroyed by fire on April 6, 1915. During the latter part of 1915 the Tintic Milling Co. was organized, and a new chloridizing-roasting plant was partly constructed on the site of the burned mill to use a combination of the Holt-Dern and Christensen processes, more particularly the roasting devices of the Holt-Dern patent. At this writing (June 15, 1916), there have been three shipments of silver precipitates containing copper and lead, and the capacity of the plant has been increased. Flotation was installed at the Garfield mills of the Utah Copper Co. to clean concentrate, and at the Utah Apex mill at Bingham to replace vanners, the Janney machines being employed. The Daly-Judge at Park City installed flotation to re-treat tailings and slimes, the Callow process being used. The same process is being installed in the Silver King Coalition mill. Below Park City two large mills were reworking old tailings and made a fair grade of zinc concentrate. Flotation is to be used in both of these mills, which at present are equipped for straight concentration. At Frisco, in Beaver County, the tailings of the Horn Silver mill will be treated in a Callow flotation plant under construction, and the "minerals separation" process is to be used on the 1,000,000-ton dump of Cactus tailings at Newhouse, where a plant is being built. In the Tintic district, at Eureka, the Utah Ore Concentrator is treating dump ore from the Chief Consolidated, Eagle & Blue Bell, and Victoria properties.

Quicksilver amounting to 30 pounds was reported to have been consumed in 1915 at milling plants and 5,356 pounds of sodium and potassium cyanide were used. This corresponds to 0.02 ounce of mercury per ounce of gold and silver and 0.021 pound of mercury per ton of ore treated. The consumption of cyanide was 0.83 pound per ounce of gold and silver and 0.44 pound per ton of ore and tailings treated.

Gold and silver produced at mills in Utah in 1915.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
Beaver, Iron, Juab, and Washington	*Short tons.* 2,167	*Fine ounces.* [a] 945.78	*Fine ounces.* [a] 496	*Fine ounces* [b] 443.10	*Fine ounces.* [b] 5,998	$32,003

[a] Includes bullion from 46 tons of old tailings.
[b] Includes bullion from 11,250 tons of old tailings.

MINE PRODUCTION.

Mine production of metals from Utah concentrates in 1915.

By counties.

	Ore to concentrating mills.	Concentrates produced.						Total value of concentrates.
		Quantity.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Beaver	12,779	5,929	293.14	86,733	138,532	2,844,345	1,572,595	$402,963
Juab	1,683	157	33.47	4,289	3	56,155	.....	5,506
Salt Lake	9,153,002	523,774	57,146.81	1,047,325	158,002,316	33,427,405	5,491,359	31,614,745
Summit	64,547	20,429	861.55	540,265	249,946	9,975,250	2,359,306	1,096,856
Tooele	74,492	28,077	241.35	317,483	947,347	7,670,954	.....	692,274
Wasatch	63,935	17,997	443.14	468,808	255,522	8,894,074	5,412,044	1,380,678
	9,370,438	596,363	59,019.46	2,464,903	159,593,666	62,868,183	14,835,304	35,193,022

By kinds of concentrates.

Siliceous	.....	2	33.47	39	3	953	.....	758
Copper	.....	427,495	37,836.33	412,745	156,436,723	.....	.....	28,367,835
Lead	.....	149,258	20,952.08	1,887,105	3,142,093	62,004,656	.....	4,853,965
Zinc	.....	19,587	197.06	164,515	12,787	859,580	14,835,304	1,969,699
Copper-lead	.....	21	.52	499	2,060	2,994	.....	765

Four smelting plants were active in Utah in 1915, the Garfield copper plant and the Murray, Midvale, and International lead plants. The last-named plant is equipped with copper furnaces also, which were in operation. During the summer of 1915 out of a total of 19 lead stacks in Utah 14 were in operation and treated approximately 3,500 tons of charge daily—about 75 per cent of a possible furnace capacity of about 4,750 tons. It was estimated [1] that the equivalent of 12 Dwight-Lloyd sintering machines were in operation out of an installation of 16, and that they sintered daily 1,800 tons of charge out of a possible capacity of 3,000 tons. There was also in Utah further sintering capacity in the shape of Huntington & Heberlein pots capable of treating an additional 400 tons of charge daily. At two of the smelters experiments are being made for the recovery of zinc by an electrochemical process. The announcement [2] was recently made that the Murray lead plant had begun the manufacture of electrolytic zinc at the rate of about 2 tons a day. If this method is successful, it will relieve the smelter of the necessity of discarding valuable zinc from its mixed lead-zinc ore. Plans are completed for the erection of a sulphuric-acid plant at Garfield to be operated in connection with the smelter under the name of the Garfield Chemical & Manufacturing Co. The first unit is to be capable of making 100 tons of acid daily.

[1] Mining in Utah: Min. and Sci. Press, July 3, 1915, p. 15.
[2] Mining in Utah: Min. and Sci. Press, Jan. 22, 1916, p. 132.

Mine production of metals from Utah crude ore shipped to smelters in 1915.

By counties.

	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
	Short tons.	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
Beaver	12,286	221.87	153,860	260,370	4,344,549	1,417,216	$508,088
Boxelder	7,014	.....	47	328,630	38,458	2,482,578	367,182
Cache	41	.....	.....	102	.....	16,895	2,113
Emery	149	.....	125	166	262	59,075	7,429
Garfield	1	.....	11	750	.....	.....	137
Grand	2	.48	50	428	.....	.....	110
Iron	117	5.78	5,099	.....	.....	.....	2,704
Juab	268,151	42,998.30	3,990,884	5,227,202	29,350,457	2,356,086	5,498,619
Millard	39	44.41	82	968	.....	.....	1,129
Morgan	108	.....	424	228	48,501	.....	2,535
Piute	192	1,617.52	2,775	1,345	3,231	.....	35,231
Salt Lake	564,644	64,603.17	2,104,377	18,929,070	58,880,537	229,663	8,510,835
Summit	53,277	2,694.22	2,556,972	1,561,000	28,411,064	.....	2,960,574
Tooele	35,166	420.14	406,452	1,298,539	8,634,552	1,198,172	996,398
Uinta	6	.....	27	5,724	.....	.....	1,016
Utah	10,934	747.54	379,176	14,476	3,614,980	1,697,251	590,591
Wasatch	5,853	200.20	177,462	219,390	2,065,190	.....	229,568
Washington	65	.03	378	35,568	.....	.....	6,417
Weber	22	.....	22	1,943	.....	.....	351
	958,067	113,553.66	9,778,223	27,885,899	135,391,781	9,456,936	19,721,027

By kinds of ore.

Dry or siliceous	47,513	7,817.78	1,018,088	686,681	1,010,054	.....	$845,419
Copper	509,762	63,583.42	1,667,586	21,478,606	20,401	.....	5,919,566
Lead	378,352	42,088.65	7,010,661	5,369,670	133,180,077	.....	11,623,611
Zinc	17,210	.82	10,818	1,250	272,737	9,449,868	1,190,324
Copper-lead	5,216	62.99	70,836	349,692	905,896	.....	140,989
Lead-zinc	14	.....	234	.....	2,616	7,068	1,118

Mine production of metals in Utah in 1915.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total value.		
	Quantity.	Value.	Quantity.	Value.		Quantity.	Value.
	Fine oz.		*Fine oz.*			*Fine oz.*	
Beaver	.....	.....	630.23	$13,028	$13,028	279,694	$141,805
Boxelder	.....	.....	.....	.....	.....	47	24
Cache	.....	.....	.....	.....	.....	.....	.....
Emery	.....	.....	.....	.....	.....	125	63
Garfield	28.15	$582	.....	.....	582	13	7
Grand	.....	.....	.48	10	10	50	25
Iron	.....	.....	160.36	3,315	3,315	5,620	2,849
Juab	.....	.....	44,038.38	910,354	910,354	4,005,600	2,030,839
Millard	.....	.....	44.41	918	918	82	42
Morgan	.....	.....	.....	.....	.....	424	215
Piute	.....	.....	1,617.52	33,437	33,437	2,775	1,407
Salt Lake	.....	.....	121,752.33	2,516,844	2,516,844	3,152,267	1,598,200
San Juan	6.00	124	.....	.....	124	2	1
Summit	.....	.....	3,564.32	73,681	73,681	3,108,328	1,575,922
Tooele	.....	.....	746.57	15,433	15,433	732,083	371,166
Uinta	12.19	252	.....	.....	252	27	14
Utah	.....	.....	747.54	15,453	15,453	379,176	192,242
Wasatch	.....	.....	643.34	13,299	13,299	646,270	327,659
Washington	.....	.....	598.83	12,379	12,379	600	304
Weber	.....	.....	.....	.....	.....	22	11
	46.34	958	174,544.31	3,608,151	3,609,109	12,313,205	6,242,795

Mine production of metals in Utah in 1915—Continued.

County.	Copper.		Lead.		Zinc (spelter).		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Beaver	428,916	$75,060	8,589,416	$403,703	2,989,811	$370,737	$1,004,333
Boxelder	328,630	57,510	38,458	1,808	2,482,578	307,840	367,182
Cache	102	18	.....	.....	16,895	2,095	2,113
Emery	166	29	262	12	59,075	7,325	7,429
Garfield	750	131	.....	.....	.....	.....	720
Grand	428	75	.....	.....	.....	.....	110
Iron	.....	.....	.....	.....	.....	.....	6,164
Juab	5,371,534	940,019	29,406,612	1,382,111	2,356,086	292,155	5,555,478
Millard	968	169	.....	.....	.....	.....	1,129
Morgan	228	40	48,501	2,280	.....	.....	2,535
Piute	1,345	235	3,231	152	.....	.....	35,231
Salt Lake	176,936,034	30,963,806	92,310,646	4,338,600	5,721,022	709,407	40,126,857
San Juan	.....	.....	.....	.....	.....	.....	125
Summit	1,812,260	317,146	38,391,113	1,804.382	2,359,306	292,554	4,063,685
Tooele	2,257,204	395,011	16,604,954	780,433	1,198,172	148,573	1,710,616
Uinta	5,724	1,002	.....	.....	.....	.....	1,268
Utah	14,476	2,533	3,614,980	169,904	1,697,251	210,459	590,591
Wasatch	474,912	83,110	10,959,264	515,085	5,412,044	671,093	1,610,246
Washington	35,568	6,224	.....	.....	.....	.....	18,907
Weber	1,943	340	.....	.....	.....	.....	351
	187,671,188	32,842,458	199,967,437	9,398,470	24,292,240	3,012,238	55,105,070

Ore sold or treated, number of deep mines producing, and value of ores in Utah in 1914 and 1915.

County.	Ore sold or treated.		Number of deep mines producing.		Average total value per ton.[a]		Average value per ton in gold and silver.[a]	
	1915	Increase or decrease.	1914	1915	1914	1915	1914	1915
	Short tons.	*Short tons.*						
Beaver	53,814	− 40,707	21	23	$11.74	$18.66	$1.91	$2.88
Boxelder	7,014	+ 6,017	5	3	30.48	52.35	2.22	.....
Cache	41	+ 31	1	2	42.50	51.51	2.20	.....
Emery	149	+ 149	.....	1	.....	49.86	.....	.42
Garfield	1	+ 1	.....	1	.....	137.00	.....	6.00
Grand	2	− 4	1	1	53.33	55.00	22.83	17.50
Iron	867	+ 861	4	2	210.33	7.11	210.33	7.11
Juab	284,783	− 4,103	44	43	18.55	19.51	11.74	10.33
Millard	39	+ 39	.....	1	.....	28.95	.....	24.61
Morgan	108	+ 95	1	1	3.46	23.47	.23	1.99
Piute	192	− 1,265	7	4	13.38	183.49	9.84	181.48
Salt Lake	9,718,002	+1,904,651	60	67	3.31	4.13	.46	.42
Summit	193,554	+ 11,562	10	15	13.55	20.99	7.81	8.52
Tooele	111,891	+ 15,298	26	37	10.77	15.29	3.35	3.45
Unita	6	+ 6	.....	1	.....	169.33	.....	2.33
Utah	10,934	− 253	18	18	35.75	54.01	15.43	18.99
Wasatch	69,788	+ 14,828	5	4	16.33	23.07	5.67	4.89
Washington	238	+ 203	1	4	13.85	79.44	13.85	53.29
Weber	22	+ 22	.....	1	.....	15.95	.....	.50
	10,451,445	+1,907,431	204	229	4.35	5.27	1.10	.94

[a] Value per ton, placer product excluded.

REVIEW BY COUNTIES.

BEAVER COUNTY.

Mine production in Beaver County, Utah.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	21	94,521	$20,717	288,821	1,511,888	9,337,928	7,143,746	$1,110,026
1915	23	53,814	13,028	279,694	428,916	8,589,416	2,989,811	1,004,333
Decrease in 1915		40,707	7,689	9,127	1,082,972	748,512	4,153,935	105,693
Total, 1860–1915			680,593	20,481,211	42,732,610	400,134,334	25,404,650	45,188,345

The county has a record of producing gold, silver, copper, lead, and zinc amounting since 1860 in total value to $45,188,345. This includes $680,593 in gold, $19,091,712 in silver, $6,679,817 in copper, $17,112,707 in lead, and $1,623,516 in zinc. The corresponding table of production by years is given to the end of the year 1913 in Mineral Resources for 1913, Part I, page 389.

Twenty-three mines in 1915 produced 53,814 tons of ore, against 21 mines and 94,521 tons of ore in 1914. The total value of the output for gold, silver, copper, lead, and zinc decreased from $1,110,026 in 1914 to $1,004,333 in 1915. The production of all the metals decreased in quantity, but the value of both lead and zinc increased. The value of the gold decreased from $20,717 in 1914 to $13,028 in 1915; silver, from $159,718 to $141,805. The output of copper, valued at $201,081 in 1914, decreased to $75,060 in 1915; that of lead increased from $364,179 in 1914 to $403,703 in 1915; that of zinc increased from $361,331 in 1914 to $370,737 in 1915. The average value per ton of the ore, including some old slag, increased from $11.74 in 1914 to $18.66 in 1915, and the gold and silver value per ton in this ore from $1.91 to $2.88. The increase in the total value was caused chiefly by the higher prices paid for lead and zinc. Of the ore mined, 12,779 tons were concentrated and produced copper concentrates carrying values in gold and silver and having a total value of $402,963, or $67.97 per ton. The copper came from the re-treatment of old tailings at Newhouse from the Cactus mine. Crude ore shipped aggregated 12,286 tons, which was mostly oxidized ore, yielding at the smelters gold, silver, copper, lead, and zinc, having a total value of $508,088, or an average value per ton of $41.35.

Antelope district.—This district is situated nearly due west of Black Rock station, on the Salt Lake & Los Angeles Railway. Some activity was in evidence the last part of 1915, and the Antelope Star group, which was worked in the eighties by means of a 120-foot tunnel and an 80-foot winze, was reopened and some lead ore of shipping value was exposed. The main fissure is said to be 6 to 8 feet in width in limestone.

Beaver Lake district.—A small quantity of oxidized copper ore was shipped from the O. K. mine in 1915.

Jarloose district.—Some development work was performed on the Blue Ribbon property in this district, 5 miles southeast of Minersville. A small quantity of ore reported to have been produced in the district was shipped; it contained principally gold, with some silver and a trace of copper.

Lincoln district.—The Croff property was the producer of a test lot of copper ore containing gold and silver that was shipped to the smelter in 1915.

Newton district.—There were 114 tons of ore sold or treated in the district carrying principally gold, with a little silver. The larger part of the output was treated at gold and silver mills and 24 tons were shipped directly to the smelter. The Golconda Annex and Sheep Rock properties were the principal producers. In the latter part of 1915 the new gold camp of Fortuna was very active, and substantial interests undertook the development of one of the best properties in the region. At the time of writing (July, 1916) the project has apparently been abandoned and the district shows but little activity.

Rocky district.—The Old Hickory and the Copper Ranch properties produced 2,855 tons of oxidized copper ore in 1915. This ore carried some silver and was valuable to the smelter for its fluxing properties. The ore from the Old Hickory property averaged 1.5 ounces of silver per ton, and 3 per cent of copper and 36 per cent of iron.

San Francisco district.—In 1915 four producers reported the output of 46,076 tons of ore and old slag containing $9,384 in gold, 171,049 ounces of silver, 221,798 pounds of copper, 6,134,931 pounds of lead, and 2,824,183 pounds of zinc, valued in all at $773,462. In 1914 the production from 86,810 tons of ore and old slag was valued at $866,607. The Horn Silver mine was the largest producer of ore, which consisted of mixed lead sulphide and carbonate and also considerable zinc sulphide. The larger part of the output from the Horn Silver property was milled at the Midvale concentrating works, yielding lead and zinc concentrates. According to the annual report of the company the property [1] in 1915 yielded 4,241 tons of mixed carbonate and sulphide ore containing lead and silver, 1,379 tons of zinc ore, 11,816 tons of zinc-lead ore, 42 tons of copper ore, and 12,579 tons of slag from the old smelter dumps. A concentration mill using flotation to treat the tailings from the old mills, estimated at 200,000 tons, was completed by the Caldo Leasing Co. in December at a cost approximating $45,000.

The Cactus tailings have been tested by the Utah Leasing Co., which has completed a 500-ton flotation plant ready for full operation early in 1916. The dump contains approximately 1,000,000 tons of tailings averaging 15 pounds of copper per ton. According to a recent article [2] the tailings are taken to the feed hopper by a drag-line scraper and from this hopper are raised to the bins by a bucket elevator. The tailings are fed to two 8-foot by 48-inch Hardinge pebble mills, with extra large scoops, by means of two feeders. The Hardinge mills are connected in closed circuit with two Dorr Simplex classifiers, the minus 65-mesh material being sent to the elevator to a Minerals Separating machine and the oversize returned to the Hardinge mills for regrinding.

[1] Horn Silver Mining Co. Ann. Rept. for year ending Dec. 31, 1915.
[2] Min. and Sci. Press, Dec. 11, 1915, p. 899.

Star districts (North and South).—Ten producers shipped 4,693 tons of ore directly to the smelters in 1915, against 7,096 tons shipped by 6 producers in 1914. The total output was valued at $192,749, and contained $697 in gold, 103,542 ounces of silver, 21,374 pounds of copper, 2,452,716 pounds of lead, and 165,628 pounds of zinc, with an average value per ton of $41.07, as against a total output valued at $236,115 in 1914 with an average value per ton of $33.27. Most of the ore came from the Moscow property, and yielded the larger part of the lead and silver produced in the district. The Cedar Talisman mine also produced siliceous zinc ore and a small quantity of oxidized lead ore. There was also a small shipment from the Paloma prospect.

BOXELDER COUNTY.

Lucin district.—Lessees operating on the Copper Mountain group shipped oxidized copper ore.

Promontory district.—New discoveries of zinc ore called attention to the district in 1915. It is situated near the south end of the Promontory Mountains, a range that forms a long promontory on the north shore of Great Salt Lake. The south end of the promontory is crossed by the Lucin cut-off of the Southern Pacific Railroad. Promontory Point station is the post office and Saline station is the loading point for ore. The Lakeview mining camp is about 25 miles south of Promontory station on the old line of the Southern Pacific Railroad. The area in which ore has been produced is 3 or 4 miles north of the railroad at Saline and at an elevation of about 1,000 to 1,500 feet higher. The wagon road has a moderate grade for most of the distance, but is rather steep near the camp. Wagons and auto trucks were used to transport the ore to Saline. No fresh water suitable for culinary purposes has been found near the camp. It is brought in on the railroad in tank cars for the section crew at Saline and the mining camp. This region is described in further detail in a recent Survey report.[1] Prospecting by the Lakeview Mining Co. has been carried on along the outcrop for a distance of 4,500 feet. Between March 11, 1915, and the end of 1915 shipments aggregating 4,788 tons of zinc carbonate ore and 94 tons of lead carbonate were made to the smelters. The total zinc ore mined averaged 30.5 per cent of zinc and the lead ore 18.18 per cent of lead. In 981 tons of zinc ore shipped to August 1, 1915, the assays given on ore settlements averaged 7.7 per cent lead, 1.1 per cent iron, 0.2 ounce silver, a trace of gold, 32.75 per cent zinc, 0.2 per cent sulphur, 1.9 per cent moisture, and 16 per cent insoluble.

CACHE COUNTY.

Zinc ore was shipped from properties in the vicinity of Hyrum and Blacksmith Fork canyon, and also a small quantity of copper ore from the Pay Up claims near Richmond. Zinc ore was discovered in August, 1915, about 1 mile south of the mouth of Blacksmith Fork canyon and 3½ miles east of Hyrum. Here an oxidized iron cropping was followed for a mile. The most promising claim is said to have been located as a gold prospect some years ago. Hand samples of

[1] Butler, B. S., and Heikes, V. C., Notes on the Promontory district, Utah: U. S. Geol. Survey Bull. 640, pp. 1–10, 1916 (Bull. 640-A).

this ore contained as high as 42 per cent of zinc, but carload shipments, of which there were only two in 1915, averaged 28 and 22 per cent, respectively.

EMERY COUNTY.

Summerville district.—The Good Hope claims were worked for oxidized zinc ore and a small quantity carrying silver was shipped to a smelter in Oklahoma. The region from which the zinc ore was shipped in 1915 is about 10 miles west of Woodside station on the Denver and Rio Grande Railroad. The deposit occurs in shale and is described as being about 5 feet thick between limestone and sandstone beds. Samples of the best ore exposed assayed 13.5 ounces of silver per ton, and 4 per cent lead and 27.45 per cent zinc. Another sample assayed 15.9 ounces of silver, 20 cents in gold, 0.6 per cent of lead, and 40.5 per cent of zinc. An average sample of the ore face contained 1.5 per cent to 8 per cent of zinc, and 1.5 ounces to 7.5 ounces of silver per ton. The best ore (aggregating 139 tons and averaging 25 per cent of zinc) was sorted and shipped.

GRAND COUNTY.

La Sal district.—A small lot of copper ore carrying silver and a little gold was shipped from the Green Mountain property in 1915.

IRON COUNTY.

Gold Springs district.—During 1915 a clean-up around the milling works of the Jennie property resulted in the shipment of a small quantity of gold bullion.

Stateline district.—A small quantity of ore was shipped from the Ophir property, yielding principally silver and a little gold. This property was operated in 1902 and had a 150-ton mill, in which chlorination was first used and then cyanidation.

JUAB COUNTY.

Forty-three producers made an output in 1915 of 284,783 tons of ore containing gold, silver, copper, lead, and zinc, valued at $5,555,478, a decrease of 4,103 tons in quantity, and an increase of $196,498 in value, as compared with the output of 44 producers in 1914 of 288,886 tons, valued at $5,358,980. The ore was principally from the Tintic district.

Detroit district.—Considerable activity was occasioned by the opening of the Ibex property, known as the E. P. H. and Keystone claims, by lessees who shipped copper ore carrying gold and silver values.

Fish Springs district.—Three mining properties yielded 31 tons of lead ore, which was of shipping grade. The Utah mine was under bond and lease, and a small shipment of lead ore was made.

Mount Nebo district.—Three deep mines yielded 397 tons of ore, the larger part of which was valuable for its zinc content and was shipped to eastern zinc plants. The lead ores mined were sold to the smelters in Salt Lake Valley. The mines producing were the Eva, Highland, and Star.

Spring Creek district.—In 1915 the Queen of Sheba mine and mill were operated and produced gold and silver bullion and a small

quantity of lead concentrate. Another property in Johnson Canyon in this district produced a small quantity of copper-lead ore, containing a little silver and gold, which was shipped to the smelter.

Tintic district.—The total value of the metals produced from 1869 to the end of 1915 was $160,149,227, distributed as follows: Gold, $30,832,935; silver, $75,398,084; copper, $23,315,063; lead, $29,630,311; zinc, $972,834.

The larger part of Tintic district is in Juab County and the remainder in Utah County.

Mine production in Tintic district, Utah, by counties.

County.	Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
			Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Juab	1914	36	287,526	$928,905	4,406,689	5,274,672	31,542,528	247,920	$5,310,138
	1915	32	282,953	902,335	3,999,847	5,347,474	29,301,537	2,149,857	5,509,820
Utah	1914	10	10,960	24,885	260,255	15,799	4,968,383	510,297	390,699
	1915	9	10,521	14,440	371,137	10,458	3,355,481	1,695,201	572,349
	1914	46	298,486	953,790	4,666,944	5,290,471	36,510,911	758,217	5,700,837
	1915	41	293,474	916,775	4,370,984	5,357,932	32,657,018	3,845,058	6,082,169
Total, 1869–1915				30,832,935	114,599,353	145,269,267	677,676,126	11,909,556	160,149,227

The value of the metals produced was distributed as follows: Gold, $916,775 in 1915, against $953,790 in 1914; silver, $2,216,089 in 1915, against $2,580,820 in 1914; copper, $937,638 in 1915, against $703,632 in 1914; lead, $1,534,880 in 1915, against $1,423,926 in 1914; zinc, $476,787 in 1915, against $38,669 in 1914.

The larger part of the ore mined by 41 producers in 1915 was of shipping grade, and only a small tonnage was reported to have been treated at the custom concentrating plant in the district. The total value of the district output was $6,082,169, or an average value per ton of ore sold or treated of $20.72. In 1914 the output was valued at $5,700,837, or an average value per ton of $19.10. As in the previous two years, a large part of the output consisted of old dump material, which was found valuable enough to ship. The following table gives the quantity and kinds of ore produced, the number of producers, and the metallic content of each kind of ore for the year 1915:

Mine production in Tintic district, Utah, in 1915, by kinds of ore.

Kind of ore.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Dry or siliceous	13	54,933	6,134.74	932,260	667,180	907,226	.....
Copper	13	113,120	26,721.47	852,592	4,411,343	19,457	.....
Lead	30	118,330	11,490.10	2,579,375	272,595	31,669,802	.....
Zinc	14	7,029	.82	4,798	1,250	47,597	3,845,058
Copper-lead	2	62	1.85	1,959	5,564	12,936	.....
	.....	293,474	44,348.98	4,370,984	5,357,932	32,657,018	3,845,058

Ore shipped from the Chief Consolidated mine[1] in 1915 aggregated 36,412 tons which had a net value of $309,136.46 after the payment of smelting, transportation, sampling, and other charges. The metal content of this ore was 4,634 ounces of gold, 403,854 ounces of silver, 5,648 pounds of copper, 8,232,606 pounds of lead, and 622,465 pounds of zinc. The average content was 0.1273 ounce of gold and 11.09 ounces of silver per ton, and 13.61 per cent of lead (in lead ore), 1.058 per cent of copper (in copper ore), and 32.97 per cent of zinc (in zinc ore). The total average value per ton of this ore was $20.55 and its net value was $9.96. The annual report of the company says:

The following is a general description of the work done during the year 1915 and at present in progress: The 1,000 ore system, being the most southerly of the ore systems, has been stoped upward to a point 40 feet above the 600 level and downward to a point 50 feet below the 1,400 and the following intermediate points 600, 700, 800, 900, 1,000, 1,200, and 1,400 levels. The grade and size in which the ore makes throughout this system vary considerably, and with the exception of a few seams of rich ore the product can be said to be of quite ordinary grade and shows a tendency to enlarge in size but diminish in quality at the lower levels. Small quantities of zinc ore are found at the various levels in this system.

Between the above system and that known as the 1,400 ore was stoped on the 700, 800, 1,000, 1,600, and 1,800 levels. The best ore came from the 700.

The next ore system, the 1,400, was worked from the 1,300 to the 1,800 levels; from the 1,300 to the 1,400 levels the ore carried silver, but low gold values. From the 1,400 to the 1,800 silver and lead were about equal. The ore in this system was mined down to the water level, the latter being about 11 feet below the 1,800; the character of the ore at this point remains the same as above. Stoping still continues at all the elevations above referred to.

North of this 1,400 ore system ore is being worked at the 1,400, 1,600, and 1,800 levels.

In the ore zone the following development drifts are being driven: The 627 and 628 on the 1,000 ore system. The 1,607, 1,664, 1,800 South and 1,820 drifts are developing the ground between the 1,000 and 1,400 ore systems and are heading for the former. The 1,203 drift is developing the 1,400 ore system, the 1,630 1,610' and 1,800 North drifts developing the area north of the 1,400 ore system.

The drifts looking for a new ore zone are the 1,052, 1,444, and 1,445.

The Eagle & Blue Bell mine[2] produced 26,744.52 dry tons of lead-silver ore, all of which was its higher grade material. No attempt was made to move the siliceous gold-silver ores on account of the limited hoisting facilities. The ore produced contained 1,228 ounces of gold, 441,263 ounces of silver, 3,806 pounds of copper, and 8,275,734 pounds of lead, valued in all at $492,488. The following reference to the ore bodies is made in the company's annual report:

The principal development during the year was the opening in March of the No. 1 ore deposit on the 1,550 level. This ore body has proven one of the most persistent, both in metal contents and size, that was ever developed within the property, and its full extent is yet to be determined. It has not only netted the company a considerable profit, but has also demonstrated the great extent of the ore zone laterally.

Mining and development of this ore body was continued the entire year, proving its continuance for about 400 feet in length, [its average of] about 60 feet in width, and [that it extends] almost continuously for a vertical distance of 370 feet, or from a point 120 feet above the 1,550 level to a depth corresponding with the 1,800 level. Its limits have not as yet been determined. The ore occurrence appears strong in the deepest workings and it continues to make above the 1,550 level. The development of the ore body up to this time would indicate the general strike to be northerly and southerly. It parallels to the west what is known as our "East Zone" as developed on the 1,200, 1,300, 1,350, 1,425, and 1,538 levels.

From the 1,000 and 1,538 levels a small tonnage of lead-silver ore was shipped, and considerable dry ore developed around the 1,538 workings.

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[1] Chief Consolidated Mining Co. Seventh Ann. Rept. for year ending Dec. 31, 1915.
[2] Bingham Mines Co. Seventh Ann. Rept. for year ending Dec. 31, 1915.

At the Gemini mine 100 lessees were at work in May. During the year 279 cars of ore, about 40 tons each, were shipped. The water in the shaft was lowered in December to the 1,700-foot level, where some very rich sulphide lead-silver-copper ore is known to exist. The work of the Ridge and Valley mine is carried on through the Gemini. Shipments of ore were resumed in July. Good silver-lead ore was opened on the 1,600-foot level.

From the Eureka Hill mine 20 lessees shipped ore taken out of the property through the Bullion Beck shaft. The Victoria mine was turned over to the control of the Eagle & Blue Bell Co. the latter part of the year. From the Gold Chain mine 105 cars of ore were shipped during 1915. At Silver City the Tintic Milling Co., which is to use the chloridizing-roasting process in its plant, was expected to be in operation in the spring of 1916.

At the Mammoth mine all the levels have been placed in condition to work from the 600-foot down to the 1,600-foot level. A large body of low-grade copper ore is said to be opened on the 600-foot level, and shipments carry 3 to 4 per cent of copper. On the 1,500-foot level a new body of lead-silver ore is being developed. The Mammoth Co. has shipped largely from the old mine dumps during the last two years and has about exhausted the old tailing dump situated near Tintic Junction, where early milling operations were carried on. These tailings carried enough copper to make them profitable at the high price for the metal.

At the Gold Chain property the ore produced was handled through the Lower Mammoth mine at its 1,500-foot level.

The Lower Mammoth mine[1] produced 377 tons of silver-lead ore, 1,113 tons of copper ore, and 1,620 tons of zinc ore in 1915. During the early part of 1915 lessees worked in ground on levels above the 1,200-foot level, cleaning the old stopes and working on small bodies of low-grade lead and copper ores. The company mined zinc ore in a raise from the 1,700-foot level to the 1,500-foot level.

Several strikes of ore were announced in the Yankee property during the latter part of the year.

The Colorado mine[2] was operated almost exclusively under the leasing system during 1915. There were produced 1,489 tons of ore, containing 244.35 ounces of gold, 49,359 ounces of silver, 413,105 pounds of lead, and 295,865 pounds of zinc, valued in all at $53,851.95, or an average value of $36.15 per ton.

The Iron Blossom No. 1 workings[3] yielded 16,548.93 dry tons of ore, containing 2,300.20 ounces of gold, 416,424 ounces of silver, 889,793 pounds of lead, and 382,575 pounds of copper, valued in all at $293,766.63, or an average value of $17.75 per ton. The No. 3 mine workings produced 26,764 tons of ore, containing 4,374.40 ounces of gold, 837,519 ounces of silver, 4,775,356 pounds of lead, 60,670 pounds of copper, and 146,016 pounds of zinc, valued in all at $618,585.33, or an average value of $23.11 per ton. The company report says:

The winze on the 600-foot level from Iron Blossom No. 3 shaft has been sunk a total distance of 400 feet, and we are installing a new engine for the purpose of going to greater depth, as we have every confidence now that the ore discovered on the

[1] Lower Mammoth Mining Co. Ann. Rept. for year ending Dec. 31, 1915.
[2] Colorado Mining Co. Ann. Rept. for year ending Nov. 1, 1915.
[3] Iron Blossom Consolidated Mining Co. Ann. Rept. for year ending Dec. 1, 1915.

900-foot level, and also again on the 1,000-foot level, will continue. * * * We have crosscut a distance of 80 feet from the winze on the 1,000-foot level, most of this being in vein matter, and the last 20 feet high-grade copper, shipping from 9 to 16 per cent carload lots.

From the Dragon property [1] 7,804.56 dry tons of ore were shipped in 1915, containing 2,559.73 ounces of gold, 102,143.85 ounces of silver, 14,766 pounds of lead, and 490,750 pounds of copper, valued in all at $152,981.68, or an average of $19.60 per ton. There was only one shipment of lead ore (73.83 dry tons), and all the remainder was copper ore. Most of the development work in the mine was done on the 800-foot level. A large tonnage of milling ore is said to be blocked out for use at the new mill in Silver City. Only 26.5 tons of oxidized iron ore was shipped from the company's iron deposit.

In 1915 the Centennial-Eureka mine [2] produced 49,530 tons of ore, against 58,365 tons in 1914 and 100,442 tons in 1913. The following is from the company's report:

The claims have been worked since the year 1887. They have produced a great quantity of high-grade ore. The recent developments have shown ore of much lower grade, and although the possibilities of finding more ore, especially below the water level, have not been exhausted, the company is no longer depended upon as a large source of ore supply for the smelting company.

The Bullion Beck adjoins the Centennial-Eureka on its northerly boundary and is controlled by the same interests. From 1885 to 1900 the Bullion Beck was a heavy producer of smelting and milling ores and it is now being operated at a small profit under a leasing system. During 1915 it has been largely developed and a considerable quantity of zinc carbonate ore, hitherto unknown, was shipped.

West Tintic district.—The Scotia property was operated the entire year. In June there were over 1,000 tons of lead ore ready for shipment, but only one car was shipped in 1915. The transfer of the ore to the railroad has been begun with the use of a large traction engine. According to the annual report of the company [3] operating the property:

The work at the Scotia mine has not yet resulted in developing ore bodies of satisfactory size and in this respect is disappointing. The product of ore won as a result of the development work is now being hauled to the railroad for shipment to the smelter. No credit is shown on the books for this ore.

MILLARD COUNTY.

Detroit district.—A small quantity of gold ore containing a little copper and silver was shipped from the Copper Head property.

MORGAN COUNTY.

Argenta district.—The Carbonate Hill property shipped some lead sulphide ore containing a little copper and silver.

PIUTE COUNTY.

Gold Mountain district.—The Annie Laurie mine produced some siliceous gold ore of shipping grade, which also contained silver.

[1] Dragon Consolidated Mining Co. Ann. Rept. for year ending Dec. 31, 1915.
[2] United States Smelting, Refining & Mining Co. Tenth Ann. Rept., for year ending Dec. 31, 1915.
[3] Chief Consolidated Mining Co. Seventh Ann. Rept. for year ending Dec. 31, 1915.

Ohio district.—In prospecting the Dalton group, some lead sulphide ore was produced. The Wedge property was operated by lessees who shipped 22 tons of gold ore, which netted the company $13,315.65. The ore was mined from a fissure in porphyry opened by a tunnel 150 feet in length and a drift along the vein for 65 feet. The high-grade ore was found on the walls of the fissure and varied in width from half an inch to 20 inches.

SALT LAKE COUNTY.

In Salt Lake County 67 operators produced 9,718,002 tons of ore in 1915, which was 1,904,651 tons more than that produced in 1914 by 60 producers. The total average value per ton of the ore for the gold, silver, copper, lead, and zinc content increased from $3.31 to $4.13, and the gold and silver average value per ton of this ore decreased from 46 cents to 42 cents. One mining company working with steam shovels at Bingham continues to be the principal producer, shipping its ore to Garfield for concentration.

Big Cottonwood and Little Cottonwood districts.—Considerable attention was given to the development of mines in these districts, which were very productive in the early seventies and have a record up to the end of 1915 of 339,332 tons of ore, valued at $21,834,566, which includes $460,504 in gold, $11,961,574 in silver, $1,222,919 in copper, $8,160,642 in lead, and $28,927 in zinc. The table of production by years is given to the end of 1914 in Mineral Resources, Part I, page 740, for the year 1914.

Mine production in Big Cottonwood and Little Cottonwood mining districts, Utah.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	25	12,583	$7,695	242,825	214,971	2,887,109	8,804	$283,615
1915	18	24,590	8,897	445,111	334,944	12,263,403	229,663	898,041
Increase in 1915		12,007	1,202	202,286	119,973	9,376,294	220,859	614,426
Total, 1867–1915		339,332	460,504	11,466,853	7,873,641	153,627,960	238,467	21,834,566

The output of ore in 1915 was double that of 1914 and exceeded any previous year's production, with the exception of 1905, when most of the ore produced was of milling grade. The largest shipper in 1915 in the Big Cottonwood district was the Cardiff mine, and on the Alta or Little Cottonwood side the South Hecla and Michigan-Utah mines made heavy shipments. All the properties produced largely an oxidized silver-lead ore, but some lead sulphides are found in the Cardiff property, and the Maxfield ore is principally sulphide. Eighteen producers in 1915 shipped 24,590 tons of ore directly to the smelters, containing $8,897 in gold, 445,111 ounces of silver, 334,944 pounds of copper, 12,263,403 pounds of lead, and 229,663 pounds of zinc, valued in all at $898,041, or an average value per ton of $36.52. The Carbonate mine in Big Cottonwood Canyon yielded a large quantity of zinc-carbonate ore.

For many years after the ore bodies above water level had been exhausted the owners of the Maxfield mine endeavored to reach the ore beneath its adit level. This adit was driven in limestone for 2,400 feet, gaining a depth below the crest of the mountain of 1,200 feet. It crosscut several ore-bearing fissures, some of which were productive to the surface. A water course was encountered in a winze sunk below the adit level 218 feet, but on account of the excessive flow of water the undertaking was not successful until a large electric pumping plant in two units, capable of handling 1,500 gallons of water per minute, had been installed. The ore bodies are found in limestones which strike from northwest to southeast. The ore makes in the bedding plane of a banded blue and white lime and dips 45° NE. The fissures have a course from northeast to southwest, cutting across the bedding planes. In 1915 work on the 1,700-foot, or recently unwatered, level developed the downward extension of the ore shoots previously mined. Above water level the ores were carbonate of lead containing silver. Below water level the ore is sulphide of lead containing gold, silver, and copper, said to assay 25 cents to $18 in gold, 25 to 3,000 ounces of silver, 10 to 60 per cent of lead, and 1.5 to 7 per cent of copper.

The Prince of Wales property is operated by lessees. Its lowest level, the Annie adit, driven for about 1,100 feet, has crosscut the principal ore-bearing fissure, so productive in the upper levels, at a vertical depth of 579 feet. This fissure showed a streak of high-grade lead-silver ore varying in width from 3 to 10 inches, which has been followed for about 85 feet. Some of the ore shipped assayed 195 ounces of silver per ton and 50.3 per cent of lead.

The South Hecla property,[1] according to its annual printed report, produced 3,478.6 dry tons of ore mined by the company and 1,306.4 dry tons of ore mined by lessees. The following statements are made in the company's report:

> The total metal contents of the ore produced during the year on company account and lessees' account is as follows: 160.903 ounces gold, 144,066 ounces silver, 914,491 pounds lead, 507,842 pounds zinc, 33,151 pounds copper, and 399,905 pounds iron, the total net stoping profit for the year on company account and lessees' account being $39,205.55.
>
> During the year the ore developments have been confined mostly to the Wedge vein, which had been opened near the western end of the property by the so-called Wedge shaft and levels driven along the vein at an average depth of 120 feet on its dip and by some limited but important workings on the eastern end of the vein system over a mile away from the main development. The development carried on in the Wedge vein during this year was from the 250-foot level. During the year the indicated extent of the ore body has greatly increased, both vertically and horizontally, the ore being followed horizontally 275 feet in a westerly direction. Eleven inclined working raises were driven from the 250-foot level and 14 crosscuts were driven at different points, the drift, raises, and crosscuts all being in a good grade of direct smelting ore. The No. 1 raise from the 500-foot level, or Dwyer Tunnel, was retimbered up to the 250-foot level. None of these raises or shafts is for the hoisting of ore, actual mining being done by gravity to the 500-foot level. The average width of the ore is 20 feet.
>
> Regular shipments of ore did not commence until after August 1, on account of the low price of silver and the wet condition of our stopes, and during November and December but very little ore was marketed on account of the almost impassable condition of the team road, there being too much snow for the use of wagons and not enough for sleighing.

[1] South Hecla Mining Co. Ann. Rept., for year ending Dec. 31, 1915.

At the Michigan-Utah lessees operated the mines almost exclusively in 1915, getting most of their ore from the Grizzly and City Rocks workings. The Alta Tunnel & Transportation Co.'s adit had reached the 1,700-foot level before the end of 1915 and for some distance was in well-mineralized ground.

Smelter district.—A small quantity of slag was sorted from the dumps of the smelters. The output in 1915 was 228 tons, containing gold, silver, copper, and lead.

At Midvale numerous improvements were made at the milling and smelting plant of the United States Smelting Co.[1]

The following is taken from the company's report:

The United States Smelting Co. owns a lead smelter and also a lead and zinc concentrating mill at Midvale, Utah. These plants are situated on an area of 235 acres and are connected with the Denver & Rio Grande and Oregon Short Line railway systems. The smelter and mill not only treat the ores produced from the company's own mines, but purchase ores on the open market and by contract in all the Intermountain States, thus making of this unit a permanent custom lead smelter and concentrator.

The smelter has six blast furnaces and has a capacity of smelting 481,800 tons of charge per year. It is equipped with the most modern type of blast and roasting furnaces and charging apparatus and a system of bag-houses to filter the smelter fumes. The primary object of the bag-houses was to prevent the smoke becoming a nuisance, but their installation has permitted the company to recover as by-products arsenic and cadmium on a profitable scale.

The concentrating mill has a capacity of 210,000 tons of ore per year. The mill produced lead concentrate with gold and silver values, which is reduced in the adjoining lead smelter, and a zinc-iron middlings product. This latter is separated in the dry mill by means of the Huff electrostatic process into a zinc concentrate and an iron-silver-gold concentrate. The latter is smelted at Midvale; the former is under contract to a zinc smelter. By means of this concentrating plant complex ores which formerly could not be profitably handled, are now treated so as to yield a profit both to the mine and smelter. The United States Smelting Co. owns zinc smelters at Altoona, Iola, and La Harpe, Kans. These zinc smelters were purchased in order to afford an outlet to the zinc ores produced by other subsidiaries of the United States Smelting, Refining & Mining Co., but also to take advantage of the great spread between the price at which zinc ores can be purchased in the open market and the price at which spelter can be sold.

Bingham or West Mountain district.—The year 1915 included, the output of the Bingham district since 1865 is valued at $26,586,880 in gold, $31,332,627 in silver, $180,060,387 in copper, $40,172,656 in lead, and $1,766,637 in zinc, a total gross value of $279,919,185, out of which dividends (partly estimated), amounting to $42,000,000, have been paid. The table giving the production of the district by years may be consulted in Mineral Resources for 1913, Part I, page 399.

Mine production in Bingham or West Mountain district, Utah.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	29	7,800,661	$2,151,520	2,383,051	141,924,811	76,453,128	4,121,977	$25,537,240
1915	44	9,693,184	2,507,477	2,704,833	176,593,414	80,004,006	5,491,359	39,223,793
Increase in 1915	.....	1,892,523	355,957	321,782	34,668,603	3,550,878	1,369,382	13,686,553
Total, 1865–1915	.....	.....	26,586,880	42,534,369	1,209,605,582	898,572,340	24,684,052	279,919,185

[1] United States Smelting, Refining & Mining Co. Tenth Ann. Rept., for year ending Dec. 31, 1915, with statement to New York Stock Exchange dated Feb. 15, 1916.

The output of the district in 1915 was 9,693,184 tons of ore, against 7,800,661 tons in 1914 and 9,190,374 tons in 1913. The total metallic value of the ores in 1915 was $39,223,793, or an average value per ton of $4.05, against a total of $25,537,240 and with an average value per ton of $3.27 in 1914. The value of the output of gold increased from $2,151,520 in 1914 to $2,507,477 in 1915; silver, from $1,317,827 to $2,704,833; copper, from $18,876,000 to $30,903,848; lead, from $2,981,672 to $3,760,188; and zinc, from $210,221 to $680,929. Shipments of ore to the smelters amounted to 539,939 tons, against 532,130 tons in 1914, 655,634 tons in 1913, and 502,682 tons in 1912. The output of concentrating ores was 9,152,918 tons, against 7,268,472 tons in 1914 and 8,527,755 tons in 1913. The quantity of concentrates produced was 523,753 tons in 1915, against 435,903 tons in 1914 and 443,640 tons in 1913. The crude smelting ore in 1915 consisted principally of low-grade copper and lead sulphides and contained 64,152.90 ounces of gold, 1,657,604 ounces of silver, 18,590,920 pounds of copper, 46,579,595 pounds of lead, valued in all at $7,609,215, or an average value per ton of $14.09. Milling ores produced 523,753 tons of copper, lead, and zinc concentrates that contained 57,146.29 ounces of gold, 1,046,826 ounces of silver, 158,000,256 pounds of copper, 33,424,411 pounds of lead, and 5,491,359 pounds of zinc, valued in all at $31,613,981, or an average value per ton of $60.36.

Mine production in Bingham district, Utah, in 1915, by kinds of ore.

Kind of ore.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Dry or siliceous	4	498	115.28	3,455	7,908	805	.....
Copper	18	9,301,983	74,450.51	1,202,687	172,560,648	.....	.....
Lead	31	181,370	23,354.30	948,411	2,710,850	50,578,394	.....
Lead-zinc	8	209,333	17,379.10	550,280	1,314,008	29,424,807	5,491,359
	.....	9,693,184	121,299.19	2,704,833	176,593,414	80,004,006	5,491,359

The production of copper contained in concentrate from ore mined at the Utah Copper property [1] increased from 121,779,401 pounds in 1914 to 156,207,376 pounds in 1915. After making smelter deductions the net production in 1915 was 148,397,006 pounds of refined copper, 36,760 ounces of gold, and 371,712 ounces of silver, as against the net output in 1914 of 115,690,445 pounds of refined copper, 34,729 ounces of gold, and 325,351 ounces of silver. In 1915 there were 8,494,300 tons of ore treated at the Magna and Arthur concentration mills at Garfield, as against 6,470,166 tons in 1914. Dividends paid in 1915 amounted to $6,904,082.50. Paragraphs from the company's annual report are as follows:

The total dividends up to and including the dividends paid during the year under discussion aggregate $32,721,897.50. * * * During the year one churn drill hole was deepened and three additional holes were drilled, the total amount of this work being 1,365 feet. The combined measurement of the 87 holes drilled from the beginning of the development of the property is 47,756 feet, or 90.5 miles, corresponding to an average depth per hole of 549 feet. * * *

[1] Utah Copper Co. Eleventh Ann. Rept., for year ending Dec. 31, 1915.

At the close of the year 1914 the total ore-bearing area was reckoned at 226.3 acres, and no attempt was made to add to this area during 1915. However, the development work incident to operations increased the calculated average thickness of developed and partly developed ore from 465 feet to 480 feet. Revised ore reserve calculations show that at the end of the year there had been developed in the property 390,000,000 tons of ore, averaging 1.447 per cent copper. Of this quantity 270,000,000 tons are classed as fully developed and 120,000,000 tons as partly so. There was mined from the entire property prior to January 1, 1916, a total of 43,684,700 tons of ore averaging 1.453 per cent copper, and therefore the total reserves remaining amount to 346,315,300 tons, averaging 1.446 per cent copper. In making the calculations to determine the above averages there were used 65,643 assays, representing 358,803 linear feet of development work. The increase of ore reserves for the year was 3,815,300 tons in excess of the tonnage mined. Much additional ore can and will be developed at opportune times when the work can be done without interfering with other operations.

During the year there were milled at the Magna plant 5,233,300 tons of ore, an increase of 771,839 tons over the previous year, while at the Arthur plant, which was not operated until January 25, 3,261,000 tons were milled, an increase of 1,252,295 tons as compared with 1914. The total ore treated at both plants was 8,494,300 tons, as compared with 6,470,166 tons for the previous year. The Magna plant treated an average of 14,338 tons daily during the year, and the Arthur plant an average of 9,563 tons daily during the time it was actually operated.

The average grade of ore milled at both plants was slightly under 1.434 per cent copper, as compared with about 1.425 per cent copper for 1914. The average recovery at both plants was 64.13 per cent, corresponding to 18.39 pounds of copper per ton, as compared to 66.04 per cent, or 18.82 pounds of copper per ton for the previous year. The low extraction was due partly to the presence in the ore of considerable copper in the form of carbonates, but principally to crowding the mills for high production beyond the point of metallurgical efficiency. For the last six months of the year the average daily tonnage milled was 26,537, or about 33 per cent above normal capacity.

The cost of milling at Magna was 30.91 cents per ton, and at Arthur 39.02 cents, as compared with 34.35 cents and 37.55 cents, respectively, for the year 1914. The average cost of milling at both plants was 34.02 cents per ton, as compared with 35.36 cents for the previous year. The average cost for the first quarter was 41.98 cents; for the second quarter, 30.98 cents; for the third quarter, 31.66 cents; and for the fourth quarter, 34.66 cents. The higher costs for the first and fourth quarters were due to winter weather conditions and the consequent decrease in tonnage treated.

The total gross production of copper contained in concentrates was 156,207,376 pounds, and the average grade of the concentrates was 19.17 per cent, as compared with 121,779,401 pounds and 18.19 per cent copper, respectively, for the previous year. The production for the year, by quarters, and for the year 1914 was as follows:

Copper produced by Utah Copper Co. in 1914 and 1915.

Quarter.	1914	1915
	Pounds.	*Pounds.*
First	32,846,155	26,415,995
Second	40,017,562	40,799,825
Third	28,686,672	44,766,841
Fourth	20,229,012	44,224,715
	121,779,401	156,207,376

The average cost per net pound of copper produced for the year, after making allowances for smelter deductions and crediting the value of the gold and silver recovered, but without considering miscellaneous income, was 7.56 cents, as compared with 8.131 cents for the previous year. If the total net earnings of the Bingham & Garfield Railway, together with other miscellaneous income in Utah, were credited to the cost of production, the cost per pound would be 6.612 cents. These costs include all expenses of smelting, transportation, refining, and selling. The net value of the gold and silver recovered amounted to 0.620 cent per pound, as compared with 0.757 cent for 1914. All operating costs for 1915 were less than those of previous years. These costs, shown in the table below, include all fixed, general, and maintenance charges.

Average cost per ton of ore of mining, transportation, and milling in property of Utah Copper Co., 1910–1915.

Year.	Tonnage.	Mining.	Transportation.	Milling.	Total.
1910	4,340,245	$0.4097	$0.2978	$0.4663	$1.1738
1911	4,680,801	.4479	.3078	.4168	1.1725
1912	5,315,321	.4233	.2848	.4158	1.1239
1913	7,519,392	.3288	.2797	.3676	.9761
1914	6,470,166	.3232	.2782	.3536	.9550
1915	8,494,300	.2441	.2781	.3402	.8624

The Highland Boy mine[1] in 1915 produced 8,836,091 pounds of copper, 17,777,604 pounds of lead, 370,985 ounces of silver, and 19,387 ounces of gold. All the ore mined was transported over the company's aerial tramway to the International smelter and was classified as follows:

Average assay per ton of crude ore shipped from the Highland Boy mine, Utah, in 1915.

Material.	Dry ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounce.*	*Fine ounces.*	*Per cent.*	*Per cent.*
Copper-iron sulphide ore	207,119	0.075	1.02	2.22	.....
Lead sulphide ore	65,129	.06	2.92	.47	15.16

On the upper levels several small, but good grade, ore bodies were found. The incline shaft in the western territory of the upper limestone was sunk an additional 369 feet, and 4,303 feet of drifting and raising was done on the contact of the lime and quartzite. Several bodies of lead ore were found, but not of as high grade as those in the higher levels in the same limestone. Sulphide copper ore bodies have been opened on the No. 12 level, the continuation of the No. 11 level. Some of these ore bodies are of lower grade. The company's annual printed report says:

On No. 13 level exploration work was carried on during the year in the endeavor to develop the sulphide copper ore bodies exploited on the upper levels, so far with less favorable results than anticipated. This work will be continued during the coming year, but indications now are that these ore bodies will be smaller than in the upper workings. A raise from the No. 13 level has cut about half way up to the No. 12 level one of the low-grade hanging-wall ore bodies. The grade of the ore is 1.7 per cent copper, which is the same as on the No. 12 level.

A lead ore body is being opened up in the western extension of this level. This ore has recently been found, and as only 50 feet of drifting on it has been done it is not possible to make an estimate of its size or value. The ore so far has varied in width from 1 to 12 feet and averages about 30 per cent lead, 11 ounces silver, 0.06 ounce gold, and 0.8 per cent copper.

The Dalton & Lark property produced 6,419.8 dry tons of lead ore and 26,743.79 dry tons of copper sulphide ore, and the Commercial mines, belonging to the same company,[2] produced 13,210.35 dry tons of copper sulphide ore. Altogether the ores shipped from these mines contained 3,399 ounces of gold, 188,216 ounces of silver, 1,221,219 pounds of copper, and 2,244,078 pounds of lead. The following statements are from the company's annual report:

In the old workings lessees mined 6,846 dry tons of ore, the company receiving as royalty $21,964.04.

[1] Utah Consolidated Mining Co. Ann. Rept. for year ending Dec. 31, 1915.
[2] Bingham Mines Co. Seventh Ann. Rept., for year ending Dec. 31, 1915.

As compared with 1914, the shipments from the Dalton & Lark mine show an increase of 2,871.90 dry tons and $22,046.67 in smelter returns, due to increased production of copper ores.

The Commercial mine shows a considerable decrease both in tonnage and smelter returns. As pointed out in our last annual report, "the present ore reserves are chiefly valuable for smelter flux," and as the smelter did not require this material after September 1, it was necessary to discontinue operations at the Commercial at that time.

The Yosemite mine was not operated in 1915. According to the annual report of allied interests [1] work will be resumed early in 1916.

From the mines of the United States Smelting Co.[2] 94,166 tons of lead ore and 34,313 tons of copper ore were shipped in 1915. In the company's application to list its stock on the exchange in New York, the following statements were made:

These mines have been operated since the year 1899 under the present ownership and since about 1870 by earlier ownership. In 1914 they produced 194,898 tons of ore of an average value of $7.198 per ton at the mine, at an average mining cost of $2.86 per ton. Owing to the fact that the ore bodies occur in limestone, which economically precludes the blocking out of large ore reserves, only from two to three years of ore are blocked out, but the unexplored territory is large and the probability of continuing the finding of valuable ore bodies for a long period of time is great.

At the Utah Apex property [3] considerable improvement was made in its mill and mine. In the mill flotation equipment was added that consisted of one 44-foot Dorr tank, 14 Janney flotation machines, and 1 Portland filter. The company's annual report gives further information as follows:

Development was directed solely to opening ore bodies in connection with extraction of ore. No attempt was made to block out ore reserves in excess of those required for current mining operations. Development extended throughout a vertical distance of 1,200 feet. This wide range of vertical development was due to search for mill lead ore in the upper levels and to search for smelting ore in the lower horizons of the mine. The main three-compartment shaft was sunk 150 feet to the 1,300 level and this level was driven a distance of 728 feet to the Parvenue ore body.

A considerable tonnage of new ore was developed on the 700-foot level, where an extensive body of lead mill ore was encountered. As the stopes on this lead mill ore were driven upward the ore mass changed to siliceous copper ore, extensive in size and commercial in grade. The downward extension of this ore body has recently been encountered on the 800 level. In addition to the new copper ore body of the 700 level an extensive new copper ore body was exposed along the 100-foot level.

The output for the past year was the largest in the history of the mine. * * * The cost per ton for mining, including development and general expense, was $3 against $3.25 for the year 1914.

The total tonnage and the production of gold, silver, lead, and copper, establish new records in each case. The tonnage of lead shipping ore, for the past two years, has been limited by the capacity of the smelting plants for handling a class of ore carrying a high zinc component. The increase in the mill ore tonnage was made possible by the enlargement of the mill. Shipments of copper ore were confined to the last three months of the present year. The present rate of shipment of this class of ore is about 6,000 tons per month.

There were mined 174,693 tons of ore; 113,788 of this total were treated in the mill. There were produced from the mill 35,825 tons of lead concentrates. The mine output was 36,000,000 pounds of lead, 542,924 ounces of silver, and 2,780 ounces of gold. The net value per ton of combined ores handled averaged $4.85 per ton, against $4.82 per ton in 1914. The total net value of ore received from the smelter was $827,600 for the year 1915, and in the year 1914 the net smelter returns were $580,176.

The Ohio Copper property was operated in 1915 by lessees, who, according to a recent article,[4] are mining and concentrating about

[1] Bingham Mines Co. Ann. Rept. for year ending Dec. 31, 1915.
[2] United States Smelting & Refining Co. Tenth Ann. Rept., for year ending Dec. 31, 1915.
[3] Utah Apex Mining Co. Ann. Rept. for year ending Aug. 31, 1915.
[4] Eng. and Min. Jour., Aug. 19. 1916, p. 363.

2,240 tons of ore daily that carries about 21 pounds of copper to the ton. The copper minerals are finely disseminated in hard quartzite, making a high recovery by water concentration difficult. Under present milling practice a recovery of about 11 pounds of copper per ton was made. Mining by caving has been done very cheaply, the costs being around 22 cents per ton with 16 cents per ton transportation charges through the Mascotte tunnel to the mill.

During 1915 the Bingham-New Haven [1] deposits yielded 60,961 tons of ore, for which $730,019.92 was received, or an average of $11.97 per ton. The metal content consisted of 6,612 ounces of gold, 325,448 ounces of silver, 2,574,261 pounds of copper, and 4,903,906 pounds of lead. Dividends amounting to $960,493 have been paid. The Utah Metal deposits produced in 7 months 19,439 tons of ore, which sold for $352,275, or an average value per ton of $18.24. The ore contained 10,297 ounces of gold, 150,446 ounces of silver, 299,554 pounds of copper, and 4,956,183 pounds of lead.

Besides controlling the Bingham-New Haven property, the Utah Metal & Tunnel Co. derives some revenue from water piped from Middle Canyon through its tunnel 12,000 feet long, extending from a point on Carr Fork, below the Bingham-New Haven mine, through the mountain range to Middle Canyon, on the Tooele County side. Good bodies of ore were opened on the course of this tunnel, near the Carr Fork end, shipments of which are made directly to the smelter by railway. The ore and concentrate from the Bingham-New Haven property are shipped to the International smelter over the Highland Boy mine aerial tramway. About 225 tons per day of Bingham-New Haven ore is concentrated in its mill, making 90 tons of concentrate assaying about 12 per cent of lead, 3.87 ounces of silver, 27 per cent of iron, 0.8 per cent of copper, and 0.23 ounce of gold per ton. In addition, about 100 tons of crude copper ore are sent over the tramway daily to the smelter. The mill is equipped with crusher, rolls, trommels, jigs, classifiers, tube mill, table, and slimers, making several grades of jig, table, and vanner products. As an auxiliary to this mill, the installation of a flotation plant to re-treat the slimes from the gravity concentrating mill in a separate building is planned in 1916.

SUMMIT AND WASATCH COUNTIES.

The principal producing area is the Park City region, embracing the Blue Ledge, Snake Creek, and Uinta districts, all credited with an output, in 1915, of gold, silver, copper, lead, and zinc, valued at $5,673,931. This value added to the value of the production of metals since 1870 amounts to the sum of $158,128,516, which includes $4,145,295 in gold, $94,873,765 for silver, $4,194,977 for copper, $51,182,223 for lead, and $3,732,256 for zinc. The total value of dividends from the district for the period 1870–1915 is $40,427,191.

[1] Utah Metal & Tunnel Co. First Ann. Rept., for year ending Dec. 31, 1915.

Mine production in Park City mining region, Utah.

Year.	Num- of pro- ducers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.	*Value.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	15	236,952	$99,183	2,955,008	1,559,953	32,323,066	3,173,313	$3,363,215
1915	19	263,342	86,980	3,754,598	2,287,172	49,350,377	7,771,350	5,673,931
Increase or decrease in 1915	.....	+26,390	−12,203	+799,590	+727,219	+17,027,311	+4,598,037	+2,310,716
Total, 1870–1915	.....	.....	4,145,295	129,461,654	28,230,670	1,185,495,505	55,853,076	158,128,516

In 1915 the output of ore was 263,342 tons, as against 236,952 tons in 1914. The crude ore shipped directly to the smelters consisted of mixed lead carbonates and sulphides aggregating 59,130 tons and containing 2,894.42 ounces of gold, 2,734,434 ounces of silver, 1,780,390 pounds of copper, 30,476,254 pounds of lead, valued in all at $3,190,142, or an average value per ton of $53.94. The remainder of the ore (128,482 tons) was milled, the bulk of it producing 38,426 tons of concentrates, including those from 75,730 tons of creek tailings. The concentrates contained 1,304.69 ounces of gold, 1,009,073 ounces of silver, 505,468 pounds of copper, 18,869,324 pounds of lead, and 7,771,350 pounds of zinc, valued in all at $2,477,534, or an average value per ton of $64.48. In 1914 the average value per ton of shipping ore was $52.90 and of concentrates $41.49.

The Daly-Judge mine [1] produced in 1915 ore aggregating 69,744 tons, of which 63,935 dry tons were concentrated, yielding 10,828 tons of lead concentrate and 7,169 dry tons of zinc concentrate. The ratio of concentration was 5.8 to 1 of lead concentrate and 3.5 to 1 of all products combined. New crushing, grinding, and classifying machinery has been installed. Adequate slime settling has been provided and a flotation plant installed which is capable of treating all the "fines" passing through the mill. As is usual with ores of the character found in the Daly-Judge, these fines have been the source of most of the concentrating losses. There were 5,809 tons of sulphide lead ore shipped directly to the smelter. The metal content of the total output of ore was 642 ounces of gold, 644,935 ounces of silver, 10,954,273 pounds of lead, 472,441 pounds of copper, and 6,367,111 pounds of salable zinc. The 900-foot and 1,200-foot levels down to the 1,400-foot level of the Daly vein are productive. However, because of the iron content, which is not favorable for making a high-grade zinc concentrate, little effort is being made toward ore extraction on the 1,400-foot level. A large body of ore was opened in the "Back Vein," which holds excellent promise for the future. Dividends thus far paid amount to $1,155,000. The quantity and content of the ore shipped and of profits from ore milled are given in the company's report as follows:

[1] Daly-Judge Mining Co. Ann. Rept. for year ending Dec. 31, 1915.

Average metallic content of crude ore and concentrates of Daly-Judge Mining Co., Utah, in 1915.

Kind of material.	Dry ore.	Gold (per ton).	Silver (per ton).	Copper.	Lead.	Zinc.	Iron.	Sold for—
	Short tons.	*Fine oz.*	*Fine oz.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	
Crude ore shipped	5,809	0.034	30.32	1.86	17.73	10.82	7.67	$23.93
Lead concentrates shipped	10,828	.030	31.72	1.18	38.57	9.93	15.01	38.26
Zinc concentrates shipped	7,169	.015	17.41	.....	3.77	44.46	6.08	68.08

Preparations are under way for the erection of an electrolytic zinc plant to treat the Daly-Judge concentrate. The plant is planned to handle 30 to 40 tons of zinc concentrate and the zinc in solution will be deposited on aluminum cathodes, circular in form and revolving at a slow rate of speed in solution. The zinc concentrate is being stored until the new plant is finished, which it is thought will be some time during the last half of 1916.

The Snake Creek adit, which is to develop and drain the Daly-Judge ground, was completed to the 14,122-foot point at the end of January, 1916. It is expected it will cut the ore at 3,000 feet beneath the surface of the mining property. The ultimate length of the adit is 14,500 feet. Its portal is 6,932 feet above sea level and it has a grade of 0.25 per cent. The water channel is 3.5 feet deep by 4 feet wide, with a capacity of about 30 second-feet. About 300 feet of swelling ground in black limestone cut by porphyry was encountered and concrete was used 3,000 feet from the portal, where timber failed to hold. The rock near the portal is limestone dipping 20 degrees northwest and parallel with the line of the adit. This limestone continued for 900 feet, when a contact zone of hard marble and quartzite cut by numerous tongues of basic igneous rock was penetrated. At 10,193 feet from the portal the adit entered the Clayton-Peak diorite stock and has been in this formation ever since. It is a dense, tough formation and very wet. The average progress per month for the last two years has been 337 feet. The greatest progress was in August, 1915, when 436 feet was made. Since passing the 3,000-foot point the working has been almost continuously wet, and an unusual amount of trouble has been experienced since entering the diorite. Here nearly every crack is saturated with water, frequently under heavy pressure. Often there are intersecting cracks that make the ground loose and blocky, and a good deal of timber has been required.

The new mill, hoist, and equipment of the Daly-West mine was completed early in January, 1915, according to the company's printed statement,[1] from which extracts follow:

> Electric power was installed for the operation of the entire plant. This power is secured at a cost much less than [that of the] steam power formerly employed in operating the old destroyed plant. Automatic up-to-date devices in hoisting, milling, and handling the ore and waste, contribute to economic savings in labor and facilitate operations. After delays in making necessary adjustments, principally in the mill equipment, by the first of February the entire plant was in full commission, and continued to be operated during the balance of the year, barring some delays in installing replacements in the mill, and ice obstructions to the water supply in the spring, and a shortage of water for the mill during the months of October, November, and December, reducing the production of concentrates about one-half for these three months.

[1] Daly-West Mining Co. statement to stockholders dated Jan. 10, 1916.

This shortage of water supply resulted from the unusual light fall of snow the previous winter and the continuous drouth of rain, through the summer and fall, leaving the five lakes, which supply the water for our operations, more nearly dry than ever known in the past.

In 1915 the Silver King Consolidated,[1] according to its own ore statement, sold 13,719 tons of ore containing 605.21 ounces of gold, 652,076 ounces of silver, 411,086 pounds of copper, and 7,843,139 pounds of lead. This ore averaged 0.044 ounce of gold, 47.53 ounces of silver, 1.5 per cent of copper, 28 per cent of lead, and sold for $37.87 per ton. Dividends disbursed amount to $814,856.52 since the year 1914. The following extract is from the company's annual report:

The ore production has, in the main, been from the stopes through No. 4, No. 3, and No. 2 upraises from the 1,700-foot level. No ore has been stoped during the year on the 1,550-foot level. The policy pursued has been that of the removal of the ore from the lower or west boundary of the property, working upward and backfilling with the waste rock broken. The ore bodies of the vein and the associated beddings on both sides of the vein have, so far as mined, proven larger and more productive than anticipated. The vertical thickness of the ore in and adajcent to the main fissure has proven to be over 32 feet, with a width of from 4 to 30 feet. From this main ore vein ore beds varying in thickness from 1 to 5 feet have extended out into the adjoining country on both sides of the vein so that in places an ore width of 100 feet is found. The ore beds are usually of greatest thickness near the main fissure and gradually reduce in thickness as distance from the fissure is gained. The term ore beds is used for the reason that the principal ore bed on the south side of the vein is near the bottom of the ore in the fissure and the main ore bed on the north side of the vein is near the top of the ore in the fissure. The term ore beds is further used for the reason that locally as high as four different ore beds have been encountered lying one above the other, leading off laterally from the fissure, with bands of country rock intervening. * * *

Beginning with the production of first-class ore for market a percentage of second-class ore has been constantly accumulating. This has been placed in a dump by itself and a record kept of the quantity and mineral contents. Its value per ton is too low to stand wagon haul, railroad freight, and smelting cost, and, as it stands, is a worthless product. A series of practical concentration tests have been made and these show that the second-class dump may be turned into a valuable asset by the addition of a mill and aerial tramway.

At the Ontario mine[2] during 1915 shipments of ore were made on company account by lessees. The latter, after the company failed to make a profit, took over the mine above the 900-foot level. Below and above this level the company made shipments of old fillings, but found them to be very spotted, some being too low in silver to ship. The shaft is reported free from water to the 1,700-foot level, where a centrifugal pump has been installed.

In 1915 the output of lead-silver ore and concentrate from the Silver King Coalition property was greatly increased and was in excess of any production during the previous five years. It produced[3] the largest quantity of silver produced by any mine in Utah, approximately 1,800,000 ounces, and 24,000,000 pounds of lead, making it second to the Utah-Apex at Bingham as a lead producer. Though essentially not a copper mine, its ores yielded 1,200,000 pounds of copper. The mill was improved by the addition of the flotation process, which was completed December 5, and is now in use treating the slimes. With other improvements this will bring the capacity of the plant up to 600 tons of ore daily. The equipment of the Silver Hill shaft, which is 1,670 feet from the surface and 8,400 feet from

[1] Silver King Consolidated Mining Co. Ann. Rept. for fiscal year ending Feb. 1, 1916.
[2] Ontario Silver Mining Co. Ann. Rept. for year ending Dec. 31, 1915.
[3] Salt Lake Tribune, Jan. 2, 1916.

the mouth of the Alliance Tunnel, consists of equipment necessary for the sinking of its 3-compartment shaft to the contact about 1,000 to 1,200 feet deeper. Dividends paid stockholders amount to a total of $13,584,855.

The Broadwater mill (formerly Grasselli) started operations in October, re-treating the accumulated tailings on the flat surrounding the mill. These contain a small percentage of zinc. A large tonnage has been stacked to work during the winter months. The flotation process is in use. At Atkinson the Big Four mill began operations in September on a similar tailing proposition and expects to continue through the winter.

TOOELE COUNTY.

The production of 111,891 tons of ore by 37 producers in 1915 was 15,298 tons greater than the output by 26 producers in 1914. The average value per ton of the ore increased from $10.77 in 1914 to $15.29 in 1915, and the gold and silver value per ton from $3.35 to $3.45. The total value of the ore sold or treated, containing gold, silver, copper, lead, and zinc, was $1,710,616, against $1,039,785 in 1914. The county output consisted of 746.57 ounces of gold, valued at $15,433; 732,083 ounces of silver, valued at $371,166; 2,257,204 pounds of copper, valued at $395,011; 16,604,954 pounds of lead, valued at $780,433; and 1,198,172 pounds of zinc, valued at $148,573. The value of all metals increased, with the exception of gold, which showed a decrease of $1,035. The increases were: Silver, 177,045 ounces in quantity and $64,230 in value; copper, 961,916 pounds in quantity and $222,738 in value; lead, 3,636,973 pounds in quantity and $274,682 in value; and zinc, 446,075 pounds in quantity and $110,216 in value. The county output was 104,639 tons of lead ore, of which 74,492 tons were milled. The crude lead ore shipped was 27,914 tons, of which 9,456 tons were oxidized and 18,458 tons were sulphide. All of the zinc ore produced, 2,003 tons, was of shipping grade, and all of it was an oxidized product. The quantity of dry or siliceous ore decreased from 152 tons in 1914 to 15 tons in 1915. The output of copper ore was 188 tons, most of which was oxidized, and the copper-lead ore was 5,046 tons, all of which was oxidized. There were shipped directly to the smelters 35,166 tons of ore, which contained $8,685 in gold, 406,452 ounces of silver, 1,298,539 pounds of copper, 8,634,552 pounds of lead, and 1,198,172 pounds of zinc, having a total value of $996,398, or an average value per ton of $28.33. Concentrating and jigging plants produced 28,077 tons of concentrates from the treatment of 74,492 tons of ore, and yielded $4,989 in gold, 317,483 ounces of silver, 947,347 pounds of copper, 7,670,954 pounds of lead, valued in all at $692,274, or an average value per ton of $24.66.

Blue Bell district.—A small amount of work was performed on the R. E. P. group, and a lead sulphide ore containing silver and a trace of gold was produced.

Camp Floyd district.—No production was recorded from properties in the district in 1915. Some activity in the West Dip section began with the enlargement of the filtering capacity of the cyanide plant on the Daisy property, which was consolidated with South Daisy and Omaha groups. Part of this group was worked before, but owing to

its low gold content and also the small filtering facilities, extraction on a commercial scale was impossible. The cyanide mill is expected to treat, with new improvements, 125 tons of ore per day. The South Daisy shaft has been sunk to the 700-foot level. The Daisy ore shoot is said to have been opened for about 700 feet along the strike of the vein, which averaged about 5 feet in width.

Clifton district.—Ore shipped from the Mammoth, Undine, and a small prospect yielded a total of 16 tons of ore, having a total value of $530 for its gold, silver, copper, and lead content.

Columbia district.—Three producers shipped 380 tons of ore containing lead, copper, and a little gold and silver, valued in all at $8,804. The principal producer was the old Sharp mine, yielding sulphide and oxidized lead ores, which are said to average about 22 per cent lead. The Erie and Sultana properties were also producers of the same kind of ore. At the Sultana the lessees jigged some of the low-grade ore, and several small shipments of ore mixed with the concentrate were made during 1915.

Erickson district.—The O. K. property, a new producer in 1915, has been under development for two years. It can be reached either by way of Tintic Junction at the south end of the range or to the north over the old California trail, now known as the Lincoln Highway, by way of Hickman's ranch and on to Faust station of the Salt Lake Route. The present incline shaft has been sunk to a depth of 125 feet, but considerable work was also done on the vein at a lesser depth. The discovery of rich ore is said to have been made at a depth of 60 feet in November, 1915, and followed to the depth of the shaft 125 feet. The first car of 34 tons of ore, shipped the latter part of the year, assayed 488 ounces of silver and 0.23 ounce of gold per ton, and 0.15 per cent of copper. This car netted the company $9,020.08.

Granite Mountain district.—Lead ore containing a little silver was shipped from the National Copper property during the year.

Ophir district.—In 1915 the mines of the district produced 91,572 tons of ore, of which 61,161 tons were concentrated and 30,411 tons of crude ore from miscellaneous properties were shipped to the smelters. Included in the shipments were 1,783 tons of zinc ore, estimated to contain 1,099,138 pounds of metallic zinc. The principal producers were the Ophir Hill, Lion Hill, Cliff, Brooklyn, Montana, and Queen of the Hills mines.

Rush Valley district.—Reports from 8 producers show the production of 19,780 tons of ore, containing $8,230 in gold, 90,666 ounces of silver, 37,899 pounds of copper, 4,151,151 pounds of lead, and 99,034 pounds of zinc, valued in all at $268,215. There were 13,331 tons of ore milled, yielding 3,809 tons of concentrate, which, with 4,216 tons of crude ore, were shipped directly to the smelters. The Bullion Coalition, operating the Honerine property, was the principal producer, and shipments were also made from the Ben Harrison, Galena King, Muerbrook, and Calumet properties.

Silver Islet district.—Only a small quantity of lead ore, containing copper and a little silver, was shipped from two properties in the district in 1915.

Wild Cat Range district.—Shipments reported to have been made south of the Western Pacific Railway aggregated 55 tons and contained lead and copper and a little silver.

UINTA COUNTY.

Carbonate district.—Six tons of oxidized copper ore was reported shipped from one of the old properties in this district in 1915.

Green River district.—Only a small amount of gold was produced from placers in the district, as reported through the bullion buyers.

UTAH COUNTY.

Eighteen operators reported the production of 10,934 tons of ore in 1915, against 11,187 tons of ore produced by the same number of operators in 1914. The total value of the output in 1915 was $590,591, against $399,920 in 1914. The total average value per ton of the ore increased from $35.75 in 1914 to $54.01 in 1915, and the gold and silver value per ton from $15.43 to $18.99. All of the ore produced was of shipping grade.

American Fork district.—A production of 413 tons of ore was reported by 9 operators in 1915. This output is double that of 1914. In 1915 the total value of the output was $18,242, against $9,119 in 1914. The principal producer was the Pacific Gold property, producing lead ores containing silver and a little gold. The other producers were the Miller, Dutchman, Bog Iron, Bay State, and Waterfall.

Mine production in American Fork district, Utah.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ozs.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	7	224	$1,425	4,189	3,591	106,219	14,830	$9,119
1915	9	413	1,013	8,039	4,018	259,499	2,050	18,242
Increase or decrease in 1915		+189	−412	+3,850	+427	+153,280	−12,780	+9,123
Total, 1870–1915		59,739	268,474	1,804.215	112,272	27,694,346	19,592	3,743,379

Tintic district.—In 1915 the producers on the Utah County side were the Beck Tunnel, Colorado, May Day, Salvator, Sioux, Standard, Uncle Sam, Utah group, and Yankee Consolidated. The production is reviewed under Juab County, under which the operations of the more important properties in 1915 are described.

WASHINGTON COUNTY.

Bull Valley or Gold Strike district.—Two producers in 1915 reported the output of 173 tons of ore, from which was recovered $12,378 in gold and 222 ounces of silver, valued in all at $12,491, or an average value per ton of $72.20. Most of the output was from the Hamburg claims, which were worked by lessees, who erected a 3-stamp amalgamation mill in the latter part of 1914.

According to a recently published article,[1] exceptional specimens of free gold were found in fractures in limestone. The high-grade ore is itself mineralogically remarkable, occurring in a well-crystallized calcite. The lower grade is found in or near porphyritic intrusions so highly altered as to obscure their nature. The locality appears promising in so far as the milling of $5 to $20 ore is concerned. There has been too little development, however, to show its importance.

[1] Mining in Utah: Min. and Sci. Press, July 3, 1915, p. 16.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN COLORADO.[1]

(MINES REPORT.)

By Charles W. Henderson.

PRODUCTION.

GENERAL STATEMENT.

The total value of the production of gold, silver, copper, lead, and zinc in Colorado in 1915, as reported from 821 mines, of which 35 were placers, amounted to $43,426,697, an increase of $9,966,571, as compared with the yield in 1914. Of the total value, 52 per cent represented gold, the output of which was $22,414,944, an increase of $2,531,839. There was a decrease in silver of 1,768,093 fine ounces. The production of copper, which is merely incidental to the recovery of other metals, increased 473,364 pounds. The lead produced in 1915 decreased 5,401,301 pounds, the zinc produced increased 7,820,034 pounds.

ORE.

The output of ore sold or treated from Colorado mines increased 59,494 short tons in 1915 as compared with 1914.

During 1915 there were treated at amalgamating and cyaniding mills, including also a very small quantity at chlorinating mills, with or without concentration equipment (including all the custom mills of the State), 1,611,335 tons of ore having an average recovery as bullion or precipitates of 0.411 ounce of gold and 0.377 ounce of silver per ton.

From 1,611,335 tons treated at amalgamating, cyaniding, and chlorinating mills, and from 557,267 tons sent to concentration and separation mills, a total to both classes of mills of 2,168,602 tons (79 per cent of the total tonnage treated, as compared with 75 per cent in 1914), were produced 233,965 tons of concentrates—ratio of 9.27 to 1—with an average total value of $55.16 a ton, as compared with $35.95 a ton in 1914.

Ore milled in 1915, in terms of metals recovered as bullion or by concentration, averaged 0.364 ounce of gold and 1.30 ounces of silver per ton, and 0.052 per cent copper, 1.00 per cent lead, and some zinc.

[1] For discussion of the geology of the districts mentioned in the following pages the reader is directed to the bibliography appended to the report for 1912, in Mineral Resources, 1912, pt. 1, pp. 704–705, 1913, and to U. S. Geol. Survey Bull. 507, The mining districts of the western United States, by J. M. Hill, with a geologic introduction by Waldemar Lindgren, 1912.

Crude ore shipped to lead and copper smelters amounted to 436,210 tons, averaging 0.60 ounce gold and 9.45 ounces silver per ton, and 0.55 per cent copper and 2.43 per cent lead. Crude ore to spelter and zinc oxide plants amounted to 132,208 tons, averaging 23.56 per cent zinc.

All classes of concentrates to lead and copper plants amounted to 156,152 tons, averaging 0.80 ounce of gold and 12.99 ounces silver per ton, and 0.66 per cent copper and 13.20 per cent lead. Zinc and zinc-lead concentrates shipped to spelter and zinc oxide plants amounted to 77,813 tons, averaging 42.35 per cent zinc.

Crude ore and concentrates combined shipped to copper and lead plants, therefore, amounted to 592,362 tons, averaging 0.65 ounce of gold and 10.39 ounces silver, and 0.58 per cent copper and 5.27 per cent lead. Crude ore and concentrates combined shipped to spelter and zinc oxide plants amounted to 210,021 tons of 30.52 per cent zinc (original assay).

In 1915 there were 35 productive placers in Colorado which yielded $693,310 in gold and 8,669 fine ounces of silver, valued at $4,395, a total of $697,705 in gold and silver, compared with $646,409 in 1914.

Mine production of metals in Colorado in 1914 and 1915.[a]

Year.	Number of producing mines.	Ore.	Gold.		Silver.[b]	Copper.	Lead.	Zinc.	Total value.
			Placer.	Deep.					
		Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	866	2,677,526	$642,360	$19,240,745	8,796,065	6,639,173	74,211,898	96,774,960	$33,460,126
1915	821	2,737,020	693,310	21,721,634	7,027,972	7,112,537	68,810,597	104,594,994	43,426,697
Increase or decrease	−45	+59,494	+50,950	+2,480,889	−1,768,093	+473,364	−5,401,301	+7,820,034	+9,966,571

[a] A revised table showing the production of gold, silver, copper, lead, and zinc from the beginning of mining in Colorado to 1915 will be included in a separate chapter of Mineral Resources, "The history of Colorado mine production" (now in preparation).

[b] Includes placer production.

GOLD.

The total production of gold in Colorado in 1915 was 1,084,322.92 fine ounces, valued at $22,414,944, an increase of 122,477.72 fine ounces and $2,531,839 in value. This yield is the largest since the output of $22,595,571 in 1908. The record yield for the State was $28,762,036 in 1900.

The Cripple Creek district, with an increase of $1,687,378, produced $13,683,494 in gold, which was 61 per cent of the State output of gold from all sources.

The San Juan region, in Dolores, La Plata, Ouray, San Juan, and San Miguel counties, yielded $3,854,521, a decrease for the region of $115,336, following a decrease of $101,826 in 1914. Lake County yielded $2,246,152, an increase of $674,701. There were increases of $61,723 in Boulder, $31,308 in Clear Creek, $48,232 in Eagle, $91,854 in Park, $47,164 in Gunnison, $75,204 in San Juan, and smaller increases in Custer, Dolores, Mineral, Rio Grande, and Summit. There were decreases of $54,968 in La Plata, $93,977 in Ouray, and $45,554 in San Miguel, and also decreases in Chaffee and Gilpin.

Siliceous and dry ore, which was 80 per cent of all the ore sold or treated, yielded 94 per cent of all the gold produced. A little more than 2 per cent came from lead ores, 3 per cent from placers, and the remainder from copper, lead-zinc, copper-lead, and zinc ores, in the order named.

The output of placer gold from 35 placers in 1915 was $693,310, an increase of $50,950. Summit County, with 4 dredges and 7 hydraulic and sluice mines, produced nearly 88 per cent, and one dredge in Lake County produced 10 per cent of the placer yield. The greater part of the remainder came from hydraulicking in Park County and sluicing in Moffat, Chaffee, and Montrose. There were small placer yields in Clear Creek, Douglas, Grand, and Routt counties.

SILVER.

The yield of silver in Colorado in 1915 was 7,027,972 fine ounces, valued at $3,563,182, a decrease of 1,768,093 fine ounces in quantity and of $1,301,042 in value, following a decrease of 529,190 fine ounces in quantity and $768,230 in value in 1914.

Lake County for 1915 showed a decrease of 1,239,828 ounces, Mineral County a decrease of 323,927 ounces, San Miguel County a decrease of 183,820 ounces, San Juan a decrease of 63,280 ounces, and other decreases were in Boulder, Chaffee, Gilpin, Gunnison, La Plata, Ouray, Park, and Saguache. Notable increases were made in Clear Creek, Custer, Dolores, Eagle, and Pitkin.

Siliceous and dry ores yielded 74 per cent of the total; lead ores, about 14 per cent; lead-zinc ores, nearly 8 per cent; copper ores, 3 per cent; and copper-lead ores, more than 1 per cent. Zinc ores and placers furnished a negligible percentage.

COPPER.

The output of copper in 1915 increased in quantity from 6,639,173 pounds to 7,112,537 pounds and in value from $883,010 to $1,244,694. Copper is not an important mineral in the yield of the State, but it is widespread in the ores, a production being made from 23 counties.

Lake County was the leading producer of copper, yielding 25 per cent of the State output; San Juan was second, with nearly 15 per cent; and Dolores was third, with over 14 per cent.

Siliceous and dry ores yielded 61 per cent of the copper output; copper ores, more than 30 per cent; lead ores, 5 per cent; copper-lead ores, 3 per cent; and lead-zinc and zinc ores, the remainder.

LEAD.

The production of lead (in terms of lead in lead bullion and in leaded-zinc oxide) in Colorado in 1915 was 68,810,597 pounds, valued at $3,234,098, a decrease of 5,401,301 pounds in quantity but an increase of $339,834 in value.

There were heavy decreases in production in Lake and Pitkin counties, the two principal sources of that metal. Other decreases were in Chaffee, Dolores, Gunnison, Ouray, and Saguache counties. The decreases were not balanced by the increases, those of note being in the San Juan region, particularly in San Juan, San Miguel, and Mineral counties.

In rank, Lake County led, Pitkin was second, San Juan third, San Miguel fourth, Chaffee fifth, and Clear Creek, Mineral, Ouray, Summit, Eagle, Boulder, and Gilpin followed in order. There was a decrease of 50,118 tons in the quantity of lead ore produced but an increase of 116,518 tons of lead-zinc ores.

Lead ores yielded 40 per cent of the lead output; siliceous and dry ores more than 31 per cent; lead-zinc ores about 27 per cent; copper-lead ores almost 1 per cent; zinc ores and copper ores each less than 0.5 per cent.

ZINC.[1]

In 1915 the marketed zinc ores from Colorado contained 104,594,994 pounds of recoverable zinc (figured as spelter and zinc in zinc oxide and leaded-zinc oxide), with the large value of $12,969,779, an increase of only 7,820,034 pounds in quantity but of $8,034,256 in value.

Lead-zinc ores furnished 57 per cent of the total zinc yield; zinc ores, 37 per cent; and siliceous and dry ores, 6 per cent.

Lake County, with a decrease of 6,270,156 pounds, produced only 69 per cent of the zinc output of the State, as compared with 81 per cent in 1914. Leadville shipments of zinc carbonate, which were first begun in 1910, with 8,059 tons, increasing to 83,905 tons of 31 per cent zinc in 1911, to 142,782 tons of 29.2 per cent zinc in 1912, decreasing to 135,760 tons of 27.45 per cent zinc in 1913 to 113,881 tons of 24.3 per cent zinc in 1914, were only 82,592 tons of 22.48 per cent zinc in 1915. The lead-zinc and zinc-sulphide ores sold or treated in Leadville increased from 111,947 tons of 21.2 per cent zinc in 1914 to 136,555 tons of 22.09 per cent zinc in 1915.

With the exception of the decrease in Lake County and a comparatively unimportant decrease in Dolores County, all the zinc-producing counties increased their yields of zinc, in many cases very materially. The largest increases were in Eagle, Summit, and Chaffee counties, large increases were made in San Juan, San Miguel, and in Gunnison (hitherto not a large producer of zinc). Other notable increases were in Park, Clear Creek, and Fremont counties.

Zinc output from concentrates in 1915 amounted to 53,954,312 pounds and in crude ore shipped direct to smelters to 50,640,682 pounds.

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[1] For interesting discussion of zinc smelting and treatment of residues see Leslie, H. E., Zinc smelting at Bartlesville, Okla.; National Zinc Co., Bartlesville; Collinsville smelter of the Bartlesville Smelting Co., Hillsboro, Ill.; Rose Lake smelter of the Granby Co.; and Mineral Point smelter at Depue, Ill.: Min. and Sci. Press, vol. 109, pp. 44–49, July 11, 1914. Also see Stone, George C. (chief engineer New Jersey Zinc Co.), Belgian furnaces in zinc smelting: Min. and Sci. Press, Dec. 13, 1913, pp. 931–932. Stone, George C., Spelter—Manufacture and properties: Min. and Sci. Press, Nov. 14, 1914, pp. 754–759. Zinc smelter's roasting furnaces: Eng. and Min. Jour., Feb. 27, 1915, pp. 420–421. Donora Zinc Works: Min. Mag. (London), February, 1916, p. 114. Harris, T. N., New sulphuric acid plant (Donora, Pa.): Met. and Chem. Eng., Sept. 15, 1916, pp. 313–319. Simpson, W. P., The calcination of zinc carbonate: Met. and Chem. Eng., Feb. 15, 1916, pp. 181–183. Analysis and assay of zinc retort residues: Met. and Chem. Eng., Feb. 15, 1916, pp. 200–201.

Zinc ore and concentrates as marketed at the mine or mill [a] in Colorado in 1915.

County and district.	Classification.	Quantity (short tons.)	Average assay of zinc content.[b]
			Per cent.
Chaffee (ore and concentrates), Custer (ore), Fremont (ore), Gunnison (ore), Park (ore), Pitkin (ore), Saguache (ore).	Ore and concentrates	13,235	34.05
Lake	Zinc (lead) sulphide ore [c]	136,555	22.09
	Zinc carbonate ore	82,626	22.48
Eagle and Summit (ore and concentrates)	Ore and concentrates	26,875	44.28
Clear Creek (concentrates, ore, and middlings) and Gilpin (middlings).	Concentrates, ore, and middlings	2,310	40.79
San Juan region: Dolores (ore), Mineral (concentrates), Ouray (ore), San Juan (concentrates), and San Miguel (ore and concentrates).	Ore and concentrates	5,388	38.72
	Ore, concentrates, and middlings	266,989	25.53
SUMMARY.			
Lake	Crude ore	219,181	22.24
All other counties	Ore, concentrates, and middlings	47,808	40.65
		266,989	25.53
Total carbonate ore	Crude ore	89,697	23.18
Total sulphide ore	Ore, concentrates, and middlings	177,292	26.72

[a] Quantity of crude ore and contents as shipped to custom plants at Leadville, Pueblo, Canon City, and Denver, not the product from these mills, in order not to disclose individual milling operations.
[b] Assay of content; no deduction for loss in smelting.
[c] The bulk concentrated at Canon City, Denver, Pueblo, and Leadville; the remainder to spelter plants and zinc-oxide plants, chiefly in Kansas and Oklahoma, but for 1915 an increasing quantity went to Pennsylvania. Concentrates averaged 41 per cent zinc and were shipped to Kansas, Oklahoma, Illinois, Indiana, Wisconsin, Ohio, and Pennsylvania.

OUTPUT OF ORE AND METAL CONTENT.

Ore and metals produced in Colorado in 1915.

Source of production.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	.....	33,538.87	8,669	.....	.....	.....
Dry and siliceous ore	2,183,431	1,012,897.34	5,195,593	4,370,439	21,811,059	6,219,566
Copper ore	23,573	6,204.17	204,317	2,169,383	244,667	.....
Lead ore	142,969	26,068.24	964,224	338,041	27,482,225	.....
Zinc ore	100,222	28.01	24,802	412	279,154	39,168,198
Copper-lead ore	2,674	2,098.50	98,210	212,678	641,982	.....
Lead-zinc ore	284,151	3,487.79	532,157	21,584	18,351,510	59,207,230
Total, 1915	2,737,020	1,084,322.92	7,027,972	7,112,537	68,810,597	104,594,994
Total, 1914	2,677,526	961,845.20	8,796,065	6,639,173	74,211,898	96,774,960
Increase or decrease	+59,494	+122,477.72	−1,768,093	+473,364	−5,401,301	+7,820,034

The increase of 59,494 tons of ore sold or treated is directly attributable to the zinc market, there being an increase of 116,518 tons of lead-zinc ores and a decrease of 45,434 tons of strictly zinc ores, or an increase of 71,084 tons of combined zinc and lead-zinc ores. There were increases of 25,669 tons for dry and siliceous ores, 11,377 tons for copper ores, and 1,482 tons for copper-lead ores; but a decrease of 50,118 tons for lead ores. Owing to the complexity of Colorado ores, there is a considerable quantity of zinc recovered from dry ores, so that these comparisons do not entirely cover the situation. Comparing quantities of concentrates and smelting ores

of the various grades, it is found that in 1915 the zinc and lead-zinc concentrates shipped was 77,813 tons, as against 45,139 tons in 1914, and the zinc and lead-zinc ores shipped direct to smelters in 1915 was 132,208 tons, as against 164,765 tons in 1914, showing an increase of 32,674 tons of concentrates (of high grade of zinc) but a decrease of 32,557 tons of smelting ore (of comparatively low grade of zinc).

To lead smelters (with small quantity to copper-matting plants) with one exception outside the State were sent 156,152 tons of various classes of concentrates in 1915, against 143,631 tons in 1914. In 1915 436,210 tons of various classes of original ore were sent direct to smelters, as against 503,378 tons in 1914, a decrease to lead and copper plants of 54,647 tons of smelting material. This decrease of material sent to smelters within the State was compensated by the increased receipts of zinc retort residues (chiefly of Montana origin) from Oklahoma-Kansas spelter plants. The material treated by lead plants in the State therefore was about the same as usual. The lead plants are operated to a great extent on ore from other States (principally Idaho), the lead content of ore from outside the State to Colorado lead plants as compared with lead content of Colorado ore being in the ratio of about 4 to 3. In other words, Colorado mines furnish about three-sevenths of the lead ore necessary to run the Colorado smelters. The building of lead smelters in Idaho for the treatment of ore from the Coeur d' Alene district, Idaho, may seriously affect the smelting situation in Colorado.

Placer output in Colorado in 1915.

County.	Sluice and hydraulic.		Dredges.		Total.	
	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
	Fine oz.	*Fine oz.*	*Fine oz.*	*Fine oz.*	*Fine oz.*	*Fine oz.*
Chaffee	70.77	10			70.77	10
Clear Creek	41.56	6			41.56	6
Douglas	28.83	4			28.83	4
Grand	7.40	2			7.40	2
Lake			3,338.31	1,059	3,338.31	1,059
Moffat	126.40	6			126.40	6
Montrose	60.90	16			60.90	16
Park	473.69	73			473.69	73
Routt	17.95	6			17.95	6
Summit	184.72	51	29,188.34	7,436	29,373.06	7,487
Total, 1915	1,012.22	174	32,526.65	8,495	33,538.87	8,669
Total, 1914	1,920.74	389	29,153.42	6,932	31,074.16	7,321
Increase or decrease	−908.52	−215	+3,373.23	+1,563	+2,464.71	+1,348

Content of dry and siliceous gold and silver ores sold or treated in Colorado in 1915.

County.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Boulder	38,270	7,425.13	169,076	39,710	233,616	.....
Chaffee	59,854	10,511.23	147,245	231,282	2,845,503	3,256,623
Clear Creek	93,792	21,830.26	243,966	347,764	1,048,513	.....
Custer	1,304	192.22	24,800	4,301	51,791	.....
Dolores	392	70.48	5,623	10,934	21,629	.....
Eagle	4,236	4,353.06	142,947	59,132	33,648	.....
Garfield	123	256.82	112	291	.....	.....
Gilpin	52,172	22,420.30	100,503	276,968	499,350	11,000
Gunnison	2,868	1,867.70	9,852	1,078	14,712	.....
Lake	239,439	97,089.52	1,986,510	1,174,354	4,986,137	.....
La Plata	2,842	3,443.56	41,616	3,276	10,358	.....
Mineral	9,602	93.16	268,747	5,731	409,348	.....
Montezuma	14	23.90	103	.....	170	.....
Ouray	101,033	53,288.83	504,859	773,500	1,554,508	.....
Park	368	486.50	1,184	88	3,190	.....
Pitkin	4,524	.....	62,926	5,355	46,990	.....
Rio Grande	1,500	724.08	325	.....	.....	.....
Saguache	11	6.87	394	75	97	.....
San Juan	138,767	24,033.39	303,373	880,607	4,940,815	1,968,447
San Miguel	483,640	100,079.38	1,089,723	555,993	5,095,959	983,496
Summit	598	2,761.93	3,942	.....	14,725	.....
Teller	948,082	661,939.02	87,767	.....	.....	.....
Total, 1915	2,183,431	1,012,897.34	5,195,593	4,370,439	21,811,059	6,219,566
Total, 1914	2,157,762	893,819.64	6,584,493	4,395,772	19,150,122	2,948,759
Increase or decrease	+25,669	+119,077.70	−1,388,900	−25,333	+2,660,937	+3,270,807

Content of copper ores sold or treated in Colorado in 1915.[a]

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*
Baca	1	.....	8	514	.....
Boulder	66	113.76	477	3,656	.....
Chaffee	506	1.34	705	44,783	1,005
Clear Creek	296	364.85	6,631	31,100	.....
Custer	29	.....	.....	5,092	.....
Dolores	13,464	278.29	105,324	1,018,325	169,263
Fremont	1,213	32.61	3,168	127,303	30,894
Gilpin	1,510	4,665.61	13,963	198,968	.....
Gunnison	67	24.43	103	4,432	.....
Hinsdale	9	2.79	314	963	.....
Lake	4,986	564.64	56,959	570,871	10,131
Montrose	169	.88	1,057	57,320	.....
Ouray	983	60.79	5,537	70,341	21,941
Park	9	1.33	262	969	190
Pitkin	1	.....	7	481	.....
San Juan	251	91.86	9,605	30,953	10,707
San Miguel	13	.99	197	3,312	536
Total, 1915	23,573	6,204.17	204,317	2,169,383	244,667
Total, 1914	12,196	3,243.88	173,845	1,330,056	96,930
Increase	11,377	2,960.29	30,472	839,327	147,737

[a] All smelting ore.

Content of copper-lead ores sold or treated in Colorado in 1915.[a]

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*
Boulder	176	49.18	16,029	19,624	51,368
Chaffee	247	11.66	20,459	16,060	37,250
Clear Creek	1,301	1,574.49	25,150	112,306	182.038
Gunnison	28	1.62	881	1,824	6,465
La Plata	1	.03	13	220	97
Ouray	175	7.01	14,483	13,802	26,720
Saguache	254	12.17	4,726	16,525	71,951
San Juan	492	442.34	16,469	32,317	263,093
Total, 1915	2,674	2,098.50	98,210	212,678	641,982
Total, 1914	1,192	288.91	82,119	97,672	371,161
Increase	1,482	1,809.59	16,091	115,006	270,821

[a] All smelting ore.

Content of lead ores sold or treated in Colorado in 1915.

County.	Ore.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*
Boulder	1,266	172.88	85,710	23,690	602,058
Chaffee	4,654	4,465.12	56,255	49,930	684,553
Clear Creek	2,437	1,512.28	61,993	39,367	834,312
Custer	192	6.02	6,833	3,247	38,017
Dolores	282	228.44	16,545	3,221	72,203
Eagle	209	.53	8,528	213	25,871
Gilpin	370	143.31	11,199	447	91,777
Gunnison	154	1,005.67	3,163	303	32,910
Hinsdale	479	32.86	9,307	8,151	266,128
Lake	17,807	6,068.22	120,106	52,190	3,101,632
La Plata	109	16.67	4,740	618	12,907
Mineral	1,262	606.10	11,038	412	226,674
Ouray	1,052	727.13	51,565	6,208	384,439
Park	1,588	6,746.50	7,708	11,246	187,450
Pitkin	103,514	.....	383,360	14,147	19,148,226
Saguache	343	233.58	5,797	6,597	87,475
San Juan	5,368	3,570.58	96,424	110,372	1,290,049
San Miguel	188	20.83	5,841	2,628	118,786
Summit	1,695	511.52	18,112	5,054	276,758
Total, 1915	142,969	26,068.24	964,221	338,041	27,482,225
Total, 1914	193,087	30,525.24	1,532,943	746,212	41,230,726
Decrease	50,118	4,457.00	568,719	408,171	13,757,501

Content of zinc ores sold or treated in Colorado in 1915.[a]

County.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Chaffee	2,624	.....	.....	.....	.....	1,295,412
Clear Creek	85	26.51	369	412	4,443	55,067
Custer	194	.....	.....	.....	.....	30,411
Dolores	34	.....	441	.....	1,239	17,453
Eagle	962	.....	.....	.....	.....	681,665
Fremont	387	.....	.....	.....	.....	228,170
Gunnison	2,734	.....	.....	.....	.....	1,452,978
Lake	91,587	1.50	23,842	.....	268,376	34,725,890
Park	855	.....	.....	.....	.....	472,992
Pitkin	281	.....	116	.....	4,872	99,887
Saguache	17	.....	34	.....	224	6,560
Summit	462	.....	.....	.....	.....	101,713
Total, 1915	100,222	28.01	24,802	412	279,154	39,168,198
Total, 1914	145,656	2.24	1,046	435	12,491	56,294,706
Increase or decrease	−45,434	+25.77	+23,756	−23	+266,663	−17,126,508

[a] Nearly all smelting ore.

Content of lead-zinc ores sold or treated in Colorado in 1915.[a]

County.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Chaffee	355	233.44	2,322	5,991	61,816	124,320
Clear Creek	24,082	123.51	54,993	.....	458,269	1,449,965
Dolores	20	.....	.....	.....	4,113	18,483
Eagle	68,790	262.65	26,075	741	1,334,524	10,460,085
Gunnison	595	12.61	10,893	1,454	135,913	297,966
Lake	127,801	1,595.41	382,526	6,008	12,591,128	37,767,288
Mineral	17,207	899.00	12,022	2,800	1,746,106	85,984
Ouray	15	.26	177	.....	3,073	7,282
Pitkin	259	1.40	2,506	.....	65,125	115,065
Saguache	67	2.46	315	163	14,700	37,690
San Juan	3,000	97.40	4,766	214	286,932	290,779
San Miguel	113	4.19	880	621	24,996	56,625
Summit	41,847	255.46	34,682	3,592	1,624,815	8,495,698
Total, 1915	284,151	3,487.79	532,157	21,584	18,351,510	59,207,230
Total, 1914	167,633	2,891.13	414,298	69,026	13,341,468	37,531,495
Increase or decrease	+116,518	+596.66	+117,859	−47,442	+5,010,042	+21,675,735

[a] Nearly all concentrating ore.

REDUCTION MILLS.

Mineral Resources for 1912, Part I, pages 650–664, contains a complete list of the reduction mills in Colorado in 1912, with description of equipment and process. Changes in this list for 1915 have been noted in the text relating to the several counties, and reference should be made to the 1912 report for details of equipment.

Gold and silver produced at mills in Colorado, 1915.

County.	Ore to gold and silver mills.	Gold in bullion.	Silver in bullion.	Ore to concentrating mills.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Short tons.*
Boulder	11,285	684.37	32,619	23,171
Chaffee	56,476	73.96	35	.....
Clear Creek	31,665	2,538.57	4,329	76,933
Custer	450	91.91	652	194
Eagle	.....	.....	.....	68,790
Gilpin	31,527	5,642.92	1,683	15,987
Gunnison	2,630	1,370.55	921	.....
Lake	6,968	4,906.21	1,747	96,764
La Plata	.....	126.38	6	.....
Mineral	.....	.....	.....	17,207
Ouray	35,411	30,999.03	8,699	32,064
Park	200	150.39	23	.....
Pitkin	.....	.....	.....	84,309
Rio Grande	1,499	723.00	309	.....
San Juan	51,842	4,864.87	2,087	90,084
San Miguel	473,986	62,013.15	507,913	9,636
Summit	240	2,163.68	931	42,128
Teller	907,156	545,955.69	46,118	.....
Total, 1915	1,611,335	662,304.68	608,072	557,267
Total, 1914	1,630,640	612,143.58	676,231	378,743
Increase or decrease	−19,305	+50,161.10	−68,159	+178,524
Average content per ton	.....	0.4110	0.3774	.....

Mine production of metals from Colorado concentrates in 1915.

	Concentrates.	Gold.	Silver.	Copper.	Lead.	Zinc.
By counties:	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Boulder	1,499	3,209.04	77,382	5,575	228,355	.....
Chaffee	8,581	9,405.77	64,466	227,475	2,652,923	3,256,623
Clear Creek	12,170	11,235.93	158,528	191,133	1,234,175	1,449,965
Custer	65	.....	.....	.....	.....	30,411
Eagle	18,214	262.65	26,075	741	1,334,524	10,460,085
Gilpin	9,387	10,865.80	52,388	135,691	230,812	11,000
Gunnison	230	272.42	6,036	230	12,095	.....
Lake	75,607	2,441.00	353,597	7,345	9,155,629	26,929,262
Mineral	2,274	899.00	12,022	2,800	1,746,106	85,984
Ouray	9,150	15,968.45	374,259	236,711	1,530,444	.....
Pitkin	28,103	.....	164,475	11,537	13,469,845	.....
San Juan	20,758	18,694.53	307,773	892,123	5,267,845	2,259,226
San Miguel	27,284	37,970.25	581,538	555,837	5,095,742	983,496
Summit	13,291	192.49	33,266	3,592	1,606,620	8,488,260
Teller	7,352	16,598.06	2,884	.....	.....	.....
Total, 1915	233,965	128,015.39	2,214,689	2,270,790	43,565,115	53,954,312
Total, 1914	188,770	116,263.06	2,058,557	1,914,797	35,583,330	31,419,916
Increase	45,195	11,752.33	156,132	355,993	7,981,785	22,534,396
By kinds of concentrates:						
Dry and siliceous	38,674	48,693.78	239,925	533,440	1,002,164	.....
Copper	336	396.55	4,995	31,182	7,039	.....
Lead	109,919	69,197.57	1,634,252	873,671	38,076,918	.....
Copper-lead	7,223	6,276.40	149,181	616,487	2,123,575	.....
Total to lead and copper plants	156,152	124,564.30	2,028,353	2,054,780	41,209,696	.....
Zinc and lead-zinc	77,813	[a] 3,451.09	[a] 186,336	[a] 216,010	[b] 2,355,419	[c] 53,954,312
Average content:		*Fine ounces per ton.*	*Fine ounces per ton.*	*Per cent.*	*Per cent.*	*Per cent.*
Dry and siliceous	.....	1.26	6.20	0.69	1.30	.....
Copper	.....	1.18	14.87	4.64	1.05	.....
Lead	.....	.63	14.87	.40	17.32	.....
Copper-lead	.....	.87	20.65	4.27	14.70	.....
Total average	.....	.80	12.99	.66	13.20	.....
Average content zinc and lead-zinc concentrates	.....	.04	2.39	.14	1.51	[d] 42.35

[a] Recovered in zinc residues.
[b] Lead recovered in zinc residues and in leaded zinc oxide.
[c] Zinc recovered as spelter and zinc in zinc oxide.
[d] Assay of content; no deduction for loss in smelting.

Mine production of metals from Colorado crude ore shipped to smelters in 1915.

	Crude ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
By counties:	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Baca	1	.....	8	514	.....	.....
Boulder	5,322	3,867.54	161,291	81,105	661,687	.....
Chaffee	11,764	5,743.06	162,485	120,571	977,204	1,419,732
Clear Creek	13,395	11,657.40	230,245	229,816	1,293,400	55,067
Custer	1,075	106.33	30,981	12,640	89,808	.....
Dolores	14,192	577.21	127,933	1,032,480	268,447	35,936
Eagle	5,407	4,353.59	151,475	59,345	59,519	681,665
Fremont	1,600	32.61	3,168	127,303	30,894	228,170
Garfield	123	256.82	112	291	.....	.....
Gilpin	6,538	10,720.50	71,594	340,692	360,315	.....
Gunnison	3,816	1,269.06	17,935	8,861	177,905	1,750,944
Hinsdale	488	35.65	9,621	9,114	266,128	.....
Lake	377,888	97,972.08	2,214,599	1,796,078	11,801,775	45,563,916
La Plata	2,952	3,333.88	46,363	4,114	23,362	.....
Mineral	10,864	699.26	279,785	6,143	636,022	.....
Montezuma	14	23.90	103	.....	170	.....
Montrose	169	.88	1,057	57,320	.....	.....
Ouray	35,783	7,116.54	193,663	627,140	460,237	7,282
Park	2,620	7,083.94	9,131	12,303	190,830	472,992
Pitkin	24,270	1.40	284,440	8,446	5,795,368	214,952
Rio Grande	1	1.08	16	.....	.....	.....
Saguache	692	255.08	11,266	23,360	174,447	44,250
San Juan	5,952	4,676.17	120,777	162,340	1,523,751	.....

Mine production of metals from Colorado crude ore shipped to smelters in 1915—Continued.

	Crude ore.	Gold.	Silver.	Copper.	Lead.	Zinc.
By counties:	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
San Miguel	332	121.99	7,190	6,717	144,535	56,625
Summit	2,234	1,172.74	22,539	5,054	309,678	109,151
Teller	40,926	99,385.27	38,765	.....	.....	.....
Total, 1915	568,418	260,463.98	4,196,542	4,841,747	25,245,482	50,640,682
Total, 1914	668,143	202,364.40	6,053,956	4,724,376	38,628,568	65,355,044
Increase or decrease	−99,725	+58,099.58	−1,857,414	+117,371	−13,383,086	−14,714,362
By kinds of ore:						
Dry and siliceous	351,794	225,892.02	3,025,531	2,137,790	6,347,310	.....
Copper	23,573	6,204.17	204,317	2,169,383	244,667	.....
Lead	58,169	25,919.98	795,584	313,255	13,961,695	.....
Copper-lead	2,674	2,098.50	98,210	212,678	641,982	.....
Total to lead and copper plants	436,210	260,114.67	4,123,642	4,833,106	21,195,654	.....
Zinc	99,606	28.01	24,802	412	279,154	39,065,552
Lead-zinc	32,602	321.30	48,098	8,229	3,770,674	11,575,130
Total to spelter and zinc oxide plants	132,208	[a] 349.31	[a] 72,900	[a] 8,641	[b] 4,049,828	[c] 50,640,682
Average content:		*Fine ounces per ton.*	*Fine ounces per ton.*	*Per cent.*	*Per cent.*	*Per cent.*
Dry and siliceous	.....	0.64	8.60	0.30	0.90	.....
Copper	.....	.26	8.67	4.60	.52	.....
Lead	.....	.45	13.68	.27	12.00	.....
Copper-lead	.....	.78	36.73	3.98	12.00	.....
Total average	.....	.60	9.45	.55	2.43	.....
Zinc	.....	.....	.25	.....	.14	[d] 23.82
Lead-zinc	.....	.01	1.48	.01	5.78	[d] 22.78
Total average	.....	.....	.55	.....	1.53	[d] 23.56

[a] Recovered in zinc residues.
[b] Lead recovered in zinc residues and in leaded zinc oxide.
[c] Zinc recovered as spelter and zinc in zinc oxide.
[d] Assay of content; no deduction for loss in smelting.

Colorado mills consumed 6,014 pounds of quicksilver in 1915, 1 pound for every 84 tons of ore, or 1 pound for every 13.37 ounces of gold and 6.22 ounces of silver; also 39,600 pounds of potassium cyanide and 1,088,592 pounds of sodium cyanide. The cyanides combined were used at the ratio of 0.83 pound per ton of ore or tailings treated, and for every pound used there were recovered 0.51 ounce of gold and 0.51 ounce of silver.

Ore, concentrates, and tailings sent to amalgamation, cyanidation, and chlorination mills and gold and silver contained in bullion and precipitates in Colorado in 1915.

Process.	Quantity.	Gold in bullion.	Silver in bullion.
	Short tons.	*Fine oz.*	*Fine oz.*
Chlorination	(a)	3,202.89	2
Amalgamation	[b] 502,830	80,416.81	37,422
Cyanidation	[c] 1,359,391	578,684.98	570,648
	.....	662,304.68	608,072

[a] Small quantities of "specimen" metallic gold and gold tellurides, the total quantity of gangue and mineral probably being less than 1 ton.
[b] Represents original crude ore; amalgamation in many cases followed by concentration or cyanidation or both. In one case amalgamation follows concentration.
[c] Represents original crude ore, concentrates, and tailings or slimes of ore first treated by amalgamation and concentration. In one case where ore crushed in cyanide solution and bulk of product in form of cyanide precipitates, small quantity of native gold recovered on blanket tables by use of mercury.

MINING INDUSTRY.

The total gross value of the production of gold, silver, copper, lead, and zinc in Colorado in 1915 was $43,426,697, an increase of 30 per cent. This notable increase can be traced directly to the increased average value per pound of zinc, the increased gross value of that metal being $8,034,256, which appears in the returns from all the zinc-producing districts; and to an increase of $2,531,839 in gold, chiefly from Cripple Creek and Leadville districts. There was also a small increase of $361,684 in the value of copper, a comparatively unimportant factor in Colorado's mine production, and a small increase of $339,834 in the value of lead, due to the increase of 0.8 cent in the average value per pound of that metal, the yield of which declined 5,401,301 pounds. There was also a decrease in silver of 1,768,093 ounces in quantity and of $1,301,042 in value.

There was a decrease of 45 in the number of producing mines, due in part to consolidations of properties but mainly to the idleness of 33 mines in Gilpin County, small claims under individual ownership. That the number of producing mines is not a real criterion may be seen in the increased quantity of ore from Gilpin County and in the decrease in value of only 4 per cent.

The Globe, Leadville, Pueblo, Durango, and Salida smelters were operated continuously on ore from Canada, Colorado, Idaho, South Dakota, and other States, including a considerable and greatly increased quantity of zinc residues from Kansas and Oklahoma zinc smelters. The United States Zinc Co.'s zinc smelter, at Pueblo, was operated steadily on zinc-lead ores from various counties in Colorado, and also from Arizona, Idaho, Montana, Nevada, and Utah; and the wet-concentration, magnetic-separation mill was also operated steadily on low-grade zinc-lead ores and concentrates from Leadville and Telluride. The copper-matting plant at Ouray was operated during the greater part of 1915. The Western Zinc Oxide Co.'s plant,[1] at Leadville, was operated steadily from April, 1915, throughout the year, the zinc-oxide product being sold for use as a pigment, not being converted into spelter. The Western Chemical Co.'s sulphuric acid, magnetic-separation, wet-concentration plant,[2] at Denver, was operated steadily at increased capacity, as was the Empire Zinc Co.'s 200-ton magnetic-separation plant,[3] at Canon City, both treating chiefly Leadville zinc-lead sulphide ores. Cyanide precipitates and copper ore were shipped to the Omaha smelter, and copper ore and copper matte were shipped to Utah plants. Lead bullion and copper matte from lead plants were sent to the Omaha smelter and to eastern refineries.

[1] For description see Leslie, E. H., Zinc pigments and Leadville works: Min. and Sci. Press, Mar. 20, 1915, pp. 433–438; Met. and Chem. Eng., Sept. 15, 1915, pp. 631–633.

[2] For description see Colorado State Bur. Mines Thirteenth Bienn. Rept., for 1913–14, pp. 150–151, 1914.

[3] For description see Livingston, A. R., Colorado State Bur. Mines Thirteenth Bienn. Rept., for 1913–14, pp. 100–101, 1914.

Active smelting plants in Colorado in 1915.

City.	Plant.	Owner.	Class of ore.	Product.	Total furnaces.[a]
Denver	Globe	American Smelting & Refining Co.	Lead base[b]	Lead bullion and copper matte.	7
Pueblo	Pueblo	do	do	do	7
Leadville	Arkansas Valley	do	do	do	10
Durango	Durango	do	do	do	4
Salida	Salida[c]	Ohio & Colorado Smelting & Refining Co.	do	do	4
Pueblo	United States Zinc Co.	American Smelting & Refining Co.	Zinc, lead, copper, gold, silver.	Spelter and zinc dust.	1,944 retorts.
Ouray	Wanakah	Wanakah Mining Co	Pyritic copper	Copper matte	2
Florence	Florence (Old Rocky Mountain).[d]	River Smelting & Refining Co.	Zinc, lead, copper, gold, silver.	Zinc oxide, lead sulphate, copper matte.	Undergoing remodeling.
Leadville		Western Zinc Oxide Co.	Zinc carbonate	Zinc oxide	8 fire boxes.

[a] Not all used.
[b] Copper ores and copper in other ores are handled by occasionally turning a lead furnace into a copper furnace.
[c] Weeks, F. D., The Salida smelter: Am. Inst. Min. Eng. Bull. 104, pp. 1691–1695, 1915.
[d] Intermediate plant of River Smelting & Refining Co., Keokuk, Iowa, for production of electrolytic spelter.

Froth flotation for the treatment of slimes (no plant in Colorado now utilizes this process as the sole method of treatment) was introduced into 4 mills in 1914. At the end of 1915 the process was in use in 1 mill in Chaffee County; in use in 1 mill and in experimentation which later led to its installation in 2 other mills in Clear Creek County; in proposed use in 1 mill each in Gilpin, Gunnison, and Hinsdale counties; in use in 1 mill in Lake County; in experimentation which led to installation in at least 1 mill in Mineral County; in use in 1 mill in Ouray County; in use in 4 mills in San Juan County; in 3 mills in Summit County, with the probable use later in 2 other mills; and in experimentation which led to its installation in 1 plant at Victor and to the decision to install it in 2 other plants at Victor, in Teller County. In the treatment of Cripple Creek ores, it has been found by the metallurgic engineers of one large company in that district that the flotation process is equally efficient in the treatment of the gold telluride ores and in the treatment of copper, lead, and zinc-silver ores. This company has decided to change 2 of its concentration-cyanide mills into flotation plants, with greatly increased capacity; to enter the custom field; and to treat 10,000,000 to 15,000,000 tons of low-grade ore now on the dumps of its own properties. This large quantity of low-grade ore insures additional stability and dividends to the Cripple Creek district.

Cripple Creek, to the end of 1915, has produced $270,688,414 in gold. Work was resumed at the heading of the Roosevelt tunnel in March and continued throughout the year, with a continued gradual lowering of the water level, except in the Vindicator-Golden Cycle territory, where electric pumps are used.

The Golden Cycle and the Portland cyanidation mills, at Colorado Springs, were operated steadily with increased output. The large cyanide plants in the district were operated steadily, but the small plants were operated intermittently or were idle.

Lake County (Leadville and outlying districts) produced gold, silver, copper, lead, and zinc having a total gross value of $13,839,401, the largest since 1883, and an increase for the year of $4,782,104. The Arkansas Valley lead smelter, to which many improvements had been made, was operated steadily. The zinc-oxide plant, unsuccessful in 1914, was actively operated on zinc carbonate ores of 16 per cent or less. The Pingrey concentration-flotation plant was also operated steadily and the Empire Zinc Co.'s concentration magnetic-separation mill at Canon City was operated with increased capacity on Leadville zinc sulphide ores, as was the Western Chemical Co.'s wet concentration magnetic-separation plant at Denver. The unwatering of the Downtown districts by electric pumps reached a depth of 700 feet at the Penrose shaft, and a consolidation of Fryer Hill claims led later to the installation of electric pumps at the Harvard shaft. Considerable interest was shown in the development work centering on Prospect Mountain, an increased output was made from the Dolly B.-Polaris-Vega mines at the heading of the Yak tunnel, and a small output was made from Iowa Gulch mines. A dredge installed on Arkansas River, below Malta, produced $69,009 in placer gold in 70 days, the yardage handled averaging 47½ cents. The Lackawanna Gulch district continued to ship bullion and high-grade gold ore and concentrates, and silver ore in quantity continued to be shipped from the Sugar Loaf district. Zinc carbonate ore was mined and shipped from Weston Pass.

Eagle County's output came chiefly from Red Cliff, but included also a considerable quantity of silver from the Brush Creek district. The value of the output for 1915 was the largest since the discovery of ore at Red Cliff in 1879 and exceeded that of 1914 by more than $1,000,000. The value of the zinc alone was $1,381,577.

Summit County dredges and placers produced gold almost equal to the output in 1914, and the production of zinc in quantity and particularly in value greatly exceeded any previous record.

Park County's output of placer gold decreased greatly, but its output of gold and zinc from deep mines increased.

The Pitkin County (Aspen) output showed an increase in silver but a decrease in lead.

Gunnison County's output showed an important increase in gold and a large increase in zinc.

Chaffee County's output showed small changes in gold, silver, copper, and lead but a heavily increased output of zinc.

Fremont County continued to produce an appreciable quantity of copper and materially increased its output of zinc. There were increases for all metals from Custer County, but Saguache County mines were not so active as in 1914. Operations at Summitville, Rio Grande County, produced considerable gold.

The San Juan region of Dolores, La Plata, Ouray, San Juan, and San Miguel counties produced $3,854,521 in gold, 2,278,201 ounces of silver, 3,517,462 pounds of copper, 14,314,363 pounds of lead, and 3,342,565 pounds of zinc, with a total value of $6,712,378, as compared with $3,969,857 in gold, 2,515,437 ounces of silver, 2,379,639 pounds of copper, 11,861,766 pounds of lead, and 1,382,334 pounds of zinc, with a total value of $6,210,494, in 1914.

Mineral County (Creede) showed a heavy decrease in silver, which was not equalized in value by the increase in gold and lead.

Boulder, Gilpin, and Clear Creek counties produced 214,823 tons of ore, yielding $1,249,894 in gold, 790,065 ounces of silver, 1,094,012 pounds of copper, 4,008,744 pounds of lead, and 1,516,032 pounds of zinc, with a total value of $2,218,308, as compared with 168,796 tons of ore, yielding $1,167,538 in gold, 802,481 ounces of silver, 1,118,685 pounds of copper, 3,459,231 pounds of lead, and 1,080,294 pounds of zinc, with a total value of $1,950,299, in 1914. Boulder County's output showed increase in all metals except silver; Clear Creek showed increase in all metals; Gilpin County showed small decrease in all metals except lead.

Mine production of metals in Colorado in 1915.

County.	Producing mines.	Ore sold or treated.	Gold.		Silver.	
			Quantity.	Value.	Quantity.	Value.
		Short tons.	*Fine ounces.*		*Fine ounces.*	
Baca	1	1	.....	.....	8	$4
Boulder	113	39,778	7,760.95	$160,433	271,292	137,545
Chaffee	15	68,240	15,293.56	316,146	226,996	115,087
Clear Creek	102	121,993	25,473.46	526,583	393,108	199,306
Custer	23	1,719	198.24	4,098	31,633	16,038
Dolores	10	14,192	577.21	11,932	127,933	64,862
Douglas	3	.....	28.83	596	4	2
Eagle	25	74,197	4,616.24	95,426	177,550	90,018
Fremont	4	1,600	32.61	674	3,168	1,606
Garfield	1	123	256.82	5,309	112	57
Gilpin	90	54,052	27,229.22	562,878	125,665	63,712
Grand	1	.....	7.40	153	2	1
Gunnison	15	6,446	2,912.03	60,197	24,892	12,620
Hinsdale	11	488	35.65	737	9,621	4,878
Lake	101	481,620	108,657.60	2,246,152	2,571,002	1,303,498
La Plata	25	2,952	3,460.26	71,530	46,369	23,509
Mineral	9	28,071	1,598.26	33,039	291,807	147,946
Moffat	4	.....	126.40	2,613	6	3
Montezuma	1	14	23.90	494	103	52
Montrose	6	169	61.78	1,277	1,073	544
Ouray	38	103,258	54,084.02	1,118,016	576,621	292,347
Park	17	2,820	7,708.02	159,339	9,227	4,678
Pitkin	13	108,579	1.40	29	448,915	227,600
Rio Grande	3	1,500	724.08	14,968	325	165
Routt	2	.....	17.95	371	6	3
Saguache	10	692	255.08	5,273	11,266	5,712
San Juan	42	147,878	28,235.57	583,681	430,637	218,333
San Miguel	25	483,954	100,105.39	2,069,362	1,096,641	555,997
Summit	41	44,602	32,901.97	680,144	64,223	32,561
Teller	70	948,082	661,939.02	13,683,494	87,767	44,498
Total, 1915	821	2,737,020	1,084,322.92	22,414,944	7,027,972	3,563,182
Total, 1914	866	2,677,526	961,845.20	19,883,105	8,796,065	4,864,224
Increase or decrease	−45	+59,494	+122,477.72	+2,531,839	−1,768,093	−1,301,042

Mine production of metals in Colorado in 1915—Continued.

County.	Copper.		Lead.		Zinc.		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Baca	514	$90					$94
Boulder	86,680	15,169	890,042	$41,832			354,979
Chaffee	348,046	60,908	3,630,127	170,616	4,676,355	$579,868	1,242,625
Clear Creek	530,949	92,916	2,527,575	118,796	1,505,032	186,624	1,124,225
Custer	12,640	2,212	89,808	4,221	30,411	3,771	30,340
Dolores	1,032,480	180,684	268,447	12,617	35,936	4,456	274,551
Douglas							598
Eagle	60,086	10,515	1,394,043	65,520	11,141,750	1,381,577	1,643,056
Fremont	127,303	22,278	30,894	1,452	228,170	28,293	54,303
Garfield	291	51					5,417
Gilpin	476,383	83,367	591,127	27,783	11,000	1,364	739,104
Grand							154
Gunnison	9,091	1,591	190,000	8,930	1,750,944	217,117	300,455
Hinsdale	9,114	1,595	266,128	12,508			19,718
Lake	1,803,423	315,599	20,957,404	984,998	72,493,178	8,989,154	13,839,401
La Plata	4,114	720	23,362	1,098			96,857
Mineral	8,943	1,565	2,382,128	111,960	85,984	10,662	305,172
Moffat							2,616
Montezuma			170	8			554
Montrose	57,320	10,031					11,852
Ouray	863,851	151,174	1,990,681	93,562	7,282	903	1,656,002
Park	12,303	2,153	190,830	8,969	472,992	58,651	233,790
Pitkin	19,983	3,497	19,265,213	905,465	214,952	26,654	1,163,245
Rio Grande							15,133
Routt							374
Saguache	23,360	4,088	174,447	8,199	44,250	5,487	28,759
San Juan	1,054,463	184,531	6,791,596	319,205	2,259,226	280,144	1,585,894
San Miguel	562,554	98,447	5,240,277	246,293	1,040,121	128,975	3,099,074
Summit	8,646	1,513	1,916,298	90,066	8,597,411	1,066,079	1,870,363
Teller							13,727,992
Total, 1915	7,112,537	1,244,694	68,810,597	3,234,098	104,594,994	12,969,779	43,426,697
Total, 1914	6,639,173	883,010	74,211,898	2,894,264	96,774,960	4,935,523	33,460,126
Increase or decrease	+473,364	+361,684	−5,401,301	+339,834	+7,820,034	+8,034,256	+9,966,571

REVIEW BY COUNTIES.

BACA COUNTY.

A shipment of 1 ton of silver-copper ore was made from the Carrizo Creek district, in the southeast corner of this county. The ore is chalcopyrite, partly altered to malachite and azurite, in white sandstone.

Production for past years shows that there was considerable activity in this district and small shipments of ore were made during 1900–1902, but owing to the distance to a railroad (70 miles) very little work has been done in the district since that time.

BOULDER COUNTY.

Mine production in Boulder County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	147	14,591	$98,710	312,217	24,316	523,821	$295,029
1915	113	39,778	160,433	271,292	86,680	890,042	354,979
Increase or decrease, 1915	−34	+25,187	+61,723	−40,925	+62,364	+366,221	+59,950

There was an increased output in all the districts of Boulder County in 1915 with the exception of Sugar Loaf and Ward districts.

This county does not produce zinc. In 1915 there was an increase for all the other metals, except silver, and gold again resumed its position, lost in 1913 and 1914 to silver, as the most predominant metal. Lead also again increased appreciably.

The output of milling ore increased heavily, particularly that sent to mills for concentration only, with a resultant increase in the quantity of concentrates. The yield of small high-grade lots from pockets, which have always contributed considerable gold, again decreased, and the total bullion produced from all sources declined slightly in gold but increased appreciably in silver. The output of smelting ore decreased from 7,329 to 5,322 tons. The contents of the ore smelted showed an increase in gold, a heavy decrease in silver, and increases in copper and lead.

Central district.—The production of the Central district (near Jamestown) was 724 tons of ore carrying $6,986 in gold, 29,870 ounces of silver, 39,137 pounds of copper, and 459,636 pounds of lead, with a total value of $50,582, as compared with $15,846 in 1914. With the exception of a very small quantity of gold from small lots of high-grade gold ore to the Watts custom chlorination plant at Boulder, all the ore was shipped to smelters. This is the largest output from this district for several years. The Alice was the principal producing mine. Other producing mines were the Argo, Chancellor, Golden Age, Longfellow, Maybelle, and Rip Van Dam.

Gold Hill district.—The production of the Gold Hill district was 3,008 tons of ore, carrying $43,775 in gold, 5,173 ounces of silver, 554 pounds of copper, and 27,724 pounds of lead, with a total value of $47,798, as compared with $28,690 in 1914. Smelting ore contained the bulk of the yield from this district, the yield of high-grade specimen ore and bullion showing a decrease.

The Black Cloud concentration mill was operated as a custom plant for a period. The Gold Nugget 25-stamp amalgamation mill was operated part of the year. The Gold Hill Mining Co.'s new concentration and cyanidation mill was also operated for several months. The principal producing mines were the Alturis, Big Horn, Cold Spring, Free Nation, Gladstone, Gold Medal, Gold Nugget, Little Johnny, Myrtle, Nil Desperandum, Poorman, Richmond, Scotia, Sunshine, Western Slope, and White Rock.

Grand Island district (*Cardinal, Caribou, Eldora, Nederland*).[1]—This district, revived in 1914, was the principal producing district in the county in 1915, with a yield of 32,632 tons of ore carrying $60,802 in gold, 112,505 ounces of silver, 6,583 pounds of copper, and 240,470 pounds of lead, with a total value of $130,296, as compared with $40,730 in 1914.

The Cariman Mining & Milling Co., which in 1914 had taken over the old Caribou group, including the Caribou, Poorman, and No Name mines, at Caribou, and also the Boulder County mine and mill, at Cardinal, completed a new 100-ton cyanide plant[2] at the Caribou mine. It operated this mill on ore from the Poorman dump, and also operated the Boulder County concentration-cyanidation plant on ore from the Boulder County mine.

[1] George, R. D., and Crawford, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Ann. Rept., pp. 7–105, 1909. (Reprint with additions, pp. 1–122, 1916.)

[2] For description and flow sheet see Parmelee, H. C., Met. and Chem. Eng., August, 1915.

Small lots of smelting ore were shipped from the Fortune, Grant, and Up To Date mines.

Magnolia district.[1]—The Magnolia district in 1915 produced $11,680 in gold, 408 ounces of silver, and 4,127 pounds of lead, with a total value of $12,081, as against $10,684 in 1914. All the ore was shipped to smelters. The principal producing mines were the Cash, Kekionda, Keystone, Lady Franklin, Mountain Lion, Ophir, Poorman, and Sac and Fox.

Sugar Loaf district.—This district, which in 1914 was the principal producing district in the county, took second place to the Grand Island district in 1915. Its output was only 1,662 tons of ore, that yielded $21,257 in gold, 67,229 ounces of silver, 28,206 pounds of copper, and 14,617 pounds of lead, with a total value of $60,965, as compared with $138,541 in 1914. The bulk of the ore was shipped to smelters. The free-milling ore of the Logan mine was treated in a small laboratory plant or sold to the Watts chlorination plant, at Boulder; in addition, a good grade of smelting ore was shipped. Several cars of silver-gold ore were shipped from the Forest mine, and a large tonnage of lead-silver ore was shipped from the Yellow Pine mine. An appreciable quantity of ore carrying a good content of gold was shipped from the Herald mine. A car of ore was shipped from the Livingston mine. Bullion and smelting ore were shipped by lessees from the Wood Mountain mine. Development work was continued on the property of the United States Gold Corporation, a Herreshoff roaster was added to the equipment of the cyanidation mill, and crushing of ore was begun during the last month of the year, but no "clean-up" was made during 1915. The yield of this company for 1916 promises an increased output for the district.

Ward district.—The Ward district in 1915 produced 1,305 tons of ore, yielding $15,430 in gold, 56,093 ounces of silver, 12,200 pounds of copper, and 143,468 pounds of lead, with a total value of $52,747, as against $60,538 in 1914. Nearly all the ore was shipped to smelters. The 12-ton amalgamation, concentration, and cyanidation mill at the Lois mine was operated for five months and produced some bullion and concentrates. The principal producing mines were the Columbia, from which gold-silver ore was shipped, and the White Raven, from which a large quantity of silver-lead ore was shipped. Other producing mines were the Golden Queen, Humboldt, Innspruck, Nelson No. 2, and Sweet Home.

CHAFFEE COUNTY.

Mine production in Chaffee County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	19	61,698	$332,230	272,242	319,496	3,690,359	2,173,177	$780,029
1915	15	68,240	316,146	226,996	348,046	3,630,127	4,676,355	1,242,625
Increase or decrease, 1915	−4	+6,542	−16,084	−45,246	+28,550	−60,232	+2,503,178	+462,596

[a] Includes placer production.

[1] George, R. D., and Crawford, R. D., op. cit.

Chalk Creek district.—The Mary Murphy mine, in this district, is the principal producing mine in the county, and as a result of its operations the Chalk Creek district has for several years been the most important in the county. The ore minerals of the Mary Murphy, arranged in order of quantity, are zinc blende, galena, pyrite, and chalcopyrite, with cerusite, anglesite, and a little malachite and native sulphur in the oxidized zone; the depth of the zone from the surface is irregular and varies with different veins. The gangue, in the upper levels, consists of rhodonite and quartz, with a little calcite; in the lower levels it consists mostly of quartz and clay, with calcite and a little fluorite. Gold occurs both in the ore and in the gangue minerals, but decreases in quantity and becomes strikingly irregular in distribution in the deeper workings. Silver ore also occurs both in the ore and in the gangue minerals and lessens in quantity with depth to a greater degree than the gold.

An increased tonnage of ore was milled in the company's mill[1] (built in 1912), a wet-concentration plant, with subsidiary amalgamation and electrostatic separation of zinc, iron, and copper; to this plant a flotation plant for the treatment of slimes only was added in 1915, and it is to this installation that the increased profit is due. On the other hand, the production of crude ore, both by lessees and on company account, showed a great reduction, which will probably be still more marked during 1916.

The annual report[2] of the general manager of the Mary Murphy Gold Mining Co. for the year ending December 31, 1915, says:

> The entire milling plant was operated throughout the year with comparatively few interruptions on a basis of 175 tons daily. As stated in my last annual report this tonnage might be exceeded if the condition of the mine as to ore reserves would warrant an increase. As it is we have considerable difficulty in supplying the mill with ore of a suitable grade.
>
> Our flotation tests were successful to the degree that we were able, with methods and apparatus of our own devising, to make marketable products at a low cost, which, as will be observed, has not increased the total milling expense per ton. It would be misleading to imply that we have as yet overcome all the difficulties incidental to the use of flotation on our exceptionally complex and low-grade material; in fact, we are constantly faced by some novel and puzzling problem affecting the saving. A large part of our profit for the year may, however, be credited to the successful development of this method. We are using it only on slime, and it is improbable that we shall ever attempt to treat original ore by flotation. * * *
>
> The developments during the year opened up a considerable tonnage of ore, but less than sufficient to make up for that extracted. A large part of the ore which we are mining at this time has been rendered workable by the existing high metal prices, and could not otherwise be regarded as ore at all. As on the occasion of last year's report, the great majority of our present ore exposures are so irregular that I can not submit any estimate of tonnage of ore reserves. The reserves of broken ore are as follows:

Milling ore broken in mine, tons	12,000
Smelting ore broken in mine, tons	100

> The value of this ore, as measured by the market prices of the various metals contained, fluctuates within wide limits, almost from day to day. The net yield to be expected from it may be estimated at $125,000 and $3,000, respectively.

[1] For description and flow sheet see Parmelee, H. C., Concentration of complex sulphide ore from the Mary Murphy mine: Met. and Chem. Eng., January, 1914, pp. 21–26. See also Collins, G. E., Colorado Bur. Mines Thirteenth Bien. Rept., for 1913–14, pp. 65–71, 1914.

[2] See also Mary Murphy Gold Min. Co. Ann. Rept.: Met. and Chem. Eng., Apr. 1, 1916, p. 360; also Eng. and Min. Jour., May 27, 1916, p. 945; and Min. and Sci. Press, Apr. 22, 1916, p. 361.

While I am unable to make any reliable estimate of ore reserves, * * * I would state that, while the quantity of ore available is clearly less than it was at the time I wrote my last annual report, I feel safe in saying that it will suffice to keep the mill in operation, at its present capacity, for six months, and perhaps for a year. * * *

During the year the ore milled and the ore and mill products shipped were as follows, compared with the corresponding figures for 1913 and 1914:

	1913		1914		1915	
	Tons.	Value.	Tons.	Value.	Tons.	Value.
Into concentration mill	34,271.00		48,526.00		55,880.00	
Lead concentrates					1,925.31	$168,483.60
Iron-copper concentrates					1,741.32	43,470.31
Zinc concentrates					4,700.36	327,570.10
Company concentrates	4,069.25	$160,136.46	6,136.86	$211,217.48	8,366.99	539,524.01
Company bullion (ounces)	477.20	5,635.80	424.97	5,289.43	49.73	613.83
Company crude ore	1,694.21	62,538.46	3,297.55	83,653.16	2,642.49	61,075.79
Tributors' crude ore	5,904.20	168,287.04	3,743.79	99,850.49	1,830.12	38,931.28

Several shipments of ore were made from the Iron Chest mine and small shipments from the Flora Bell and La Bastile mines.

Four Mile district.—A small quantity of placer gold was recovered from sluicing operations in the Granite district. The placer ground on Cache Creek was an important producer of placer gold by hydraulicking prior to 1911, but the operations were stopped in that year because of the pollution of the water of Arkansas River, which affected the water supply of the towns of Canon City and Pueblo. Small lots of ore were shipped from the Margaret and Yankee Blade mines.

Monarch district.[1]—From eight mines 6,385 tons were shipped, yielding $20,888 in gold; 103,331 ounces of silver, 22,389 pounds of copper, 282,218 pounds of lead, and 1,295,412 pounds of zinc, with a total value of $251,090, as compared with $129,563 in 1914.

The Madonna mine was again the chief producer,[2] shipping gold-silver-copper-lead ore and particularly increased quantity of zinc carbonate ore. Operations at this mine were steady until July 17, when work was suspended on account of collapse of the shaft. A new vertical shaft was begun and had been sunk 229 feet at the end of 1915. Lead and zinc carbonate and sulphide ores were shipped from various other properties. Other producing mines were the Fairplay, Flossie D., Giant Eclipse, Great Monarch, Hawkeye, Jewel, Lilly,[3] and Silent Friend. The Garfield mine[3] was idle. The Standard Gold-Copper Co., operating the Sunlight mine and 10-stamp amalgamation and concentration mill, continued experimentation with the mill and shipped a small quantity of bullion and concentrates.

Riverside district.—A small shipment of lead-zinc ore was made from the Harvard mine during the year.

Turret district (including Sedalia).[4]—Lessees operating the Sedalia mine shipped a large quantity of silver-copper oxidized ore to

[1] For discussion of the geology of the district see Crawford, R. D., Geology and ore deposits of the Monarch and Tomichi districts, Colo.: Colorado State Geol. Survey Bull. 4, 1913.

[2] For the total output of mine, including 1911, see Crawford, R. D., idem, p. 239.

[3] Crawford, R. D., idem, p. 262.

[4] Lindgren, Waldemar. Notes on copper deposits in Chaffee, Fremont, and Jefferson counties, Colo.: U. S. Geol. Survey Bull. 340, pp. 157–174, 1908.

the Arkansas Valley plant at Leadville, and also zinc sulphide ore to the Pingrey flotation plant at Leadville. The Brown's Canon bench gravel placer was operated for a period with a rocker.

CLEAR CREEK COUNTY.[1]

Mine production in Clear Creek County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	101	101,366	$495,275	345,387	367,790	2,435,692	1,067,314	$884,615
1915	102	121,993	[a] 526,583	393,108	530,949	2,527,575	1,505,032	1,124,225
Increase, 1915	1	20,627	31,308	47,721	163,159	91,883	437,718	239,610

[a] Includes placer production.

The gross value of the mine production of Clear Creek County in 1915 was the largest since 1907. An increase was shown from both the lower Clear Creek mines (Idaho Springs, Cascade, Jackson, Montana, and Trail districts combined) and the upper Clear Creek mines (Alice, Argentine, Empire, and Griffith districts), but the upper Clear Creek mines were responsible for 80 per cent of the increase in gross value. This increase was mainly due to the larger output and the greatly increased value of zinc. The upper Clear Creek mines, however, also showed an increased production of $22,240 in gold, 3,723 ounces of silver, 72,945 pounds of copper, and 342,277 pounds of lead. Lower Clear Creek mines showed an increase of $9,068 in gold, 43,969 ounces of silver, 90,212 pounds of copper, but a decrease of 250,394 pounds of lead.

For the first time in several years there was an appreciable quantity of placer gold produced in this county, a shaft sunk under the dump of the Stanley mine having reached gold-bearing gravels, which were hoisted and sluiced. Several smaller similar operations below the town of Idaho Springs added a small quantity of placer gold.

Alice (Yankee) district.—The output of the Alice district was $3,275, mostly gold, as compared with $890 in 1914. An increased quantity of ore from the Clara mine was treated in the 5-stamp amalgamation and concentration mill on the property. Small but increased quantities of ore from the Puritan mines and from the Reynolds Brothers mine were milled at the Reynolds Brothers 5-stamp amalgamation and concentration mill and a small output from the Ada Bell and Independence mines was treated in the Martin 2-stamp amalgamation and concentration mill.

Argentine district.—The Argentine district produced from 4 mines 4,925 tons of ore, yielding $40,911 in gold, 42,756 ounces of silver, 142,212 pounds of copper, 505,000 pounds of lead, and 18,927 pounds of zinc, with a total value of $113,557, as compared with $78,900 in 1914.

[1] For discussion of geology see Spurr, J. E., and Garrey, G. H., Preliminary report on the ore deposits of the Georgetown mining district, Colorado: U. S. Geol. Survey Bull. 260, pp. 99–120, 1905; the Idaho Springs mining district, Colorado: U. S. Geol. Survey Bull. 285, pp. 35–40, 1906; Economic geology of the Georgetown quadrangle (together with the Empire district), Colorado, with general geology by S. H. Ball: U. S. Geol. Survey Prof. Paper 63, 422 pp., 1906.

Lead ore was shipped to the Georgetown sampler from the Josephine mine. A large quantity of copper-lead ore was shipped to the Georgetown sampler and the Salida smelter from the Santiago mine. The Waldorf mine and mill were reopened and a considerable tonnage of copper-lead smelting ore was shipped and a large quantity of ore was treated in the mill by concentration on tables and jigs, which yielded lead and copper-lead concentrates. Operations at this mine were continuous throughout the year, but the production was small until August, when both the mine and mill were placed in active operation under company management. A car of zinc ore was shipped from the Mary Etta mine.

Empire (Upper Union) district.—The Empire district in 1915 from 11 mines produced 1,802 tons, yielding $12,662 in gold, 2,420 ounces of silver, 383 pounds of copper, 42,192 pounds of lead, and 5,807 pounds of zinc, with a total value of $16,659, as compared with $28,063 in 1914. As usual, most of the ore from this district was treated by milling either in the district or at Idaho Springs, only 115 tons being sent to smelters.

The Conqueror mine was reopened and a considerable quantity of ore was treated by concentration at the mill on the property, and in addition, some ore was shipped to the Argo mill at Idaho Springs. The Bard Creek Mining Co.'s mill was operated for a short period. The small quantity of ore from the General Harrison mine was treated by concentration, and a lead concentrate was shipped to the sampler at Idaho Springs and a zinc concentrate was shipped to the Western Chemical Co., Denver. A small tonnage from the Crown Price mine was treated by amalgamation and concentration. The Pioneer concentration mill was operated for a short period. Small shipments of ore were made from the E. K. M. A. mine and from the Gold Dirt mine. Small shipments of gold ore were made from the Belgian Hare, Gold Dirt, and Silver Mountain mines to the Argo mill, at Idaho Springs, and small shipments of ore were also made from the Animosa and Bellevue-Hudson mines.

Georgetown (Griffith, Silver Plume) district.—The Georgetown district in 1915 produced from 15 mines 35,205 tons of ore yielding $39,143 in gold, 88,719 ounces of silver, 26,092 pounds of copper, 801,872 pounds of lead, and 1,466,718 pounds of zinc, with a total value of $308,251, as compared with $142,448 in 1914. The output of ore in 1915 was 6,387 tons more than in 1914. The production of gold increased only $2,155, silver increased 23,242 ounces, copper increased 4,782 pounds, lead increased 252,933 pounds, and zinc increased 584,209 pounds in quantity and $136,865 in value. The production of zinc from this district represented 97 per cent of the county yield.

The 250-ton amalgamation and concentration mill of the Capital Co. was operated throughout the year. The Onondago Mining Co. operating the Ruler and Comet mines through the Capital adit, also shipped some ore to the Capital mill. Considerable development work was done on the mines of both properties. The Capital Central mine, opened by a crosscut adit 400 feet long, 200 feet of which was done in 1915, shipped lead-zinc ore to concentration plants at Georgetown. A large quantity of lead-zinc sulphide ore, being old dump and stope material from the Mendota-Frost-

burg group worked through the Victoria 2,000-foot adit, was treated in the company's 50-ton Hartz jigs and Cardtable concentration mill. A large quantity of lead-zinc sulphide ore from various properties was treated at the Graham concentration mill, the product being a lead and a zinc concentrate. Lead-zinc ore from the Smuggler mine was treated in concentration mills in the district. A small shipment of lead ore was made from the Terrible-Dunderberg mine. Small quantities of lead ore were shipped from the Dives-Pelican-Seven-Thirty-Zero group, and some lead-zinc ore from this group was treated in concentration mills in the district. The Mineral Chief mine and mill were operated for a period. Small lots of smelting ore were shipped from various other properties.

Idaho Springs district.—In the Idaho Springs district are included the mines about Idaho Springs, including Banner, Cascade, Coral, Jackson, Lower Fall River, Payne's Bar, Spanish Bar, and Virginia Canyon subdistricts.

In 1915 the Idaho Springs district produced 58,647 tons of ore, as compared with 62,587 tons in 1914. Including $859 in placer gold and 6 ounces of placer silver, the production of metals in 1915 was $376,403 in gold, 236,772 ounces of silver, 341,432 pounds of copper, 1,059,232 pounds of lead, and 13,580 pounds of zinc, with a total value for the five metals of $607,665, as compared with $575,694 in 1914. In 1915, of the 58,647 tons of ore mined, 20,428 tons were treated at amalgamation and cyanidation mills having concentration equipment and 28,235 tons were treated at mills for concentration only, a total to both classes of mills of 48,663 tons, yielding 6,647 tons of concentrates (ratio 7 to 1). These concentrates and 9,984 tons of crude ore, 16,631 tons in all, were shipped to smelters and contained all the metals produced by the mines in this district (with the exception of the placer gold and 2,538.37 ounces of gold, valued at $52,473, and 4,329 ounces of silver, valued at $2,195, contained in amalgamation bullion and cyanide precipitates).

Operated through the Big Five tunnel, the Lake mine, which has been an important producer from an ore body encountered at the tunnel level in April, 1914, continued to ship throughout the year 1915 a large quantity of smelting and concentrating ore of good commercial content in gold and silver and also some copper. Silver-lead ore was also shipped from the East Lake lode, operated through a tunnel cutting the upper levels of the property several hundred feet below the mountain ridge separating Clear Creek and Gilpin counties. The Lake vein outcrops in Clear Creek County but dips north at such an angle that at approximately 2,000 feet, where the ore is encountered in the Big Five tunnel, surveys would indicate that the ore is on the Gilpin side of a vertical line separating the two counties. Small quantities of ore from the Belman, Dove's Nest, and Edgar mines were also shipped to mills and smelters through the Big Five tunnel. Ore from the upper levels of the Specie Payment mine was sent to the Black Hawk sampler, but most of the ore was taken out through the Two Brothers tunnel and sent to custom mills or to the sampler at Idaho Springs. In Virginia Canyon, the producing mines were the Bald Eagle, Bellview-Champion, Calvin, Treasure Vault, Trio, Victor, and Windsor Castle. Through the Argo (Newhouse) tunnel the Gem Consolidated Mines continued to be the principal producing property. A large quantity of ore was

mined from the Golden Edge mine and shipped to smelters and various mills. Some ore was also shipped from the Sun and Moon group. An increased output of ore from mines in Gilpin County—the Tremont (formerly called Gunnell), Pozo-Dyke, and Kansas mines—was trammed through the Argo tunnel and sold or treated at Idaho Springs. The output and the recovered metals from this ore are credited to Gilpin County. At the mouth of the Argo tunnel, the Argo[1] 20-stamp cyanidation and concentration mill was operated steadily. Experimentation in the use of the froth flotation process begun in 1915 at this mill resulted in the complete abandonment of the cyanide process and the installation of the flotation process in June, 1916. Ore from the Franklin mine, in Gilson Gulch, was shipped to the sampler. A small quantity of ore from the Idaho-Bride mine (worked through the Idaho tunnel) was milled at the reconstructed Mixsell mill. On the south of Clear Creek, the Little Mattie mine continued to be an important producer of ore which was sent to smelters and to its own amalgamation and concentration mill. A small output of smelting ore was made from the Gladstone mine. Several small lots of ore from the Quito mine were concentrated. Lessees on the Stanley mine shipped a small quantity of ore to the sampler or to custom mills. A small production was made from the Lincoln mine. Several lots of silver-lead ore were shipped from the Almaden mine, on Fall River.

A small production was made from the Humboldt mine, in the Cascade district.

The mills operated at Idaho Springs in 1915 were the Argo, Combination, Hudson, Jackson, Payne (Mixsell), and Newton.

Montana (Lawson and Dumont) district.—The Montana district in 1915, from 10 mines, produced 283 tons of ore, carrying $3,925 in gold, 2,834 ounces of silver, 9,274 pounds of copper, and 11,896 pounds of lead, with a total value of $7,544, as against $11,209 in 1914. All but a small quantity of ore went to smelters. Producing mines were the Albro, Avalanche, Heliotrope, Platts, Princess, Senator, Skidoo, Silver Treasure, and Syndicate.

Trail Creek (Lamartine and Freeland) district.—The Trail Creek district in 1915, from 7 mines, produced 20,594 tons of ore, yielding $50,300 in gold, 19,548 ounces of silver, 11,520 pounds of copper, and 107,383 pounds of lead, with a total value of $67,274 as against $47,411 in 1914.

The Oneida 50-ton concentration and cyanide mill, placed in operation in December, 1914, was operated as a cyanidation mill for only two months when froth-flotation superseded cyanidation. It was then operated continuously throughout the year. The New Era 25-ton concentration plant was operated from March until November. Lessees operating the Lamartine mine shipped ore to the sam-

[1] For description see U. S. Geol. Survey Mineral Resources, 1912, pt. 1, p. 653, 1913; Eng. and Min. Jour., Aug. 30, 1913, pp. 385–389; and Colorado State Bur. Mines Twelfth Bienn. Rept., 1911–12, p. 80, 1913.

See also Roller, A. H., and Curran, H. T., Ore treatment at the Argo mill: Eng. and Min. Jour., p. 1, July 4, 1914.

Eng. and Min. Jour., Aug. 1, 1914, p. 217.

Pearce, J. A., Cyanidation of Clear Creek and Gilpin County sulphides: Min. and Sci. Press, Nov. 28, 1914, pp. 833–837.

Heizer, O. F., Colorado State Bur. Mines Thirteenth Bienn. Rept., 1913–14, pp. 87–90, 1914.

Parmelee, H. C., Cyanidation of low-grade sulphide ores in Colorado: Met. and Chem. Eng., July, 1915, pp. 421–425.

Pearce, J. A., Flotation versus cyanidation: Met. and Chem. Eng., July 15, 1916 pp. 706–708; Flotation tribulations: Min. and Sci. Press, Sept. 16, 1916, pp. 427–430

pler at Idaho Springs and to the 50-ton concentration plant on the property. Several shipments of gold-silver ore were made from the United Freeland mine, and small shipments were also made from the Donaldson and Gum Tree mines.

CONEJOS AND RIO GRANDE COUNTIES.

Platoro-Gilmore-Summitville district.[1]—In the Summitville district, Rio Grande County, an important production of gold-silver bullion was derived from operations on the Bonanza mine and a small shipment of gold ore was made from the Esmond mine. No work was done on the property of the Guadalupe Mining Co., near Jasper.

In Conejos County development work was done at the property of the Smuggler-Sunbeam Co.

COSTILLA COUNTY.

Grayback district.[2]—No production was made in this district in 1915.

CUSTER COUNTY.[3]

From 23 mines in Custer County in 1915 there were sold or treated 1,719 tons of ore, from which were recovered $4,098 in gold; 31,633 ounces of silver, valued at $16,038; 12,640 pounds of copper, valued at $2,212; 89,808 pounds of lead, valued at $4,221; and 30,411 pounds of zinc, valued at $3,771; a total value of $30,340, as compared with $13,268 in 1914. There were increases in all the metals, that of silver being the largest. The greater part of the ore from this county was shipped to smelters.

At Ilse dump ore from the Bassick mine was treated in the 35-ton cyanide plant. Small shipments of ore to smelters were made from the Bassick, Miners Delight, and Terrible[4] mines. At Silver Cliff smelting ore was shipped from the Augustin, Bull Domingo, Clarita, Herman, King of the Carbonates, Last Chance, Nodoway, Passiflora, Pioneer, Precipitate, Quartz King, Twenty-Six, Van Emmet, and White mines.

DOLORES COUNTY.

Mine production in Dolores County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	10	6,905	$7,973	86,526	350,278	492,023	366,549	$140,292
1915	10	14,192	11,932	127,933	1,032,480	268,447	35,936	274,551
Increase or decrease, 1915		+7,287	+3,959	+41,407	+682,202	−223,576	−330,613	+134,259

[1] For discussion of the geology of the district see Hills, R. C., Ore deposits of the Summit district, Rio Grande County, Colo.: Colorado Sci. Soc. Proc., vol. 1, pp. 20–36, 1883. Raymond, R. W., Mines and mining west of the Rocky Mountains, vol. 10, p. 329, 1875. Emmons, W. H., The enrichment of sulphide ores: U. S. Geol. Survey Bull. 529, p. 226, 1913.

[2] For discussion of geology see Patton, Smith, Butler, and Hoskins, Geology of the Grayback mining district, Costilla County, Colo.: Colorado State Geol. Survey Bull. for 1909, No. 2, 1910.

[3] For discussion of geology see Cross, Whitman, Geology of Silver Cliff and the Rosita Hills, Colo.: U. S. Geol. Survey Seventeenth Ann. Rept., pt. 2, pp. 263–403, 1896, and Emmons, S. F., The mines of Custer County: Idem, pp 405–472.

[4] For discussion of geology see Hunter, J. F., Some cerusite deposits in Custer County, Colo.: U. S. Geol, Survey Bull. 580, pp. 25–37, 1914.

Lone Cone (Dunton) district.—Small shipments of ore were made from the Emma and Rosebud mines.

Pioneer (Rico)[1] *district.*—This district in 1915 produced 14,172 tons of ore, yielding $10,829 in gold, 124,099 ounces of silver, 1,032,343 pounds of copper, 267,894 pounds of lead, and 35,936 pounds of zinc, with a total value of $271,454, as compared with $135,675 in 1914. The greater part of the ore shipped from this district was copper ore, which was sent to smelters in Utah and also to Ouray, Colo. Lead ore went to Durango, zinc ore to eastern plants, and iron ore (for its iron content only) was shipped to Vanadium, Colo., for use in the treatment of vanadium ores.[2]

The Rico-Wellington group was the principal producing property. The public report of this company states that the output for 1915 was 11,904 tons of copper ore, valued at $8.88 a ton; 18 tons of lead ore, valued at $11.69 a ton; and 629 tons of iron sulphide ore, valued at $4 a ton. The revenue from ore sales amounted to $105,573. There was 5,985 feet of development done.

Lessees on the Rico Mining Co.'s group also shipped a large quantity of ore of various classes, including some very high grade gold-silver ore. A large quantity of copper sulphide ore was shipped from the Lucky Boy group by the Rico Consolidated Mining Co. Other producing mines were the W. J. Bryan, Cobbler, Lillian D., Missouri Girl, and Swansea-Newman.

DOUGLAS COUNTY.

A small quantity of placer gold was recovered by sluicing in Newlins Gulch, near Parker, and from other localities on Cherry Creek, in Douglas County, in 1915.

EAGLE COUNTY.

Mine production in Eagle County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	24	49,377	$47,194	127,080	28,105	1,177,385	7,522,098	$550,752
1915	25	74,197	95,426	177,550	60,086	1,394,043	11,141,750	1,643,056
Increase, 1915	1	24,820	48,232	50,470	31,981	216,658	3,619,652	1,092,304

The gross value of the output of Eagle County in 1915 was by far the largest since the discovery of ore at Red Cliff in 1879. With the exception of 22,227 ounces of silver and nominal quantities of copper, lead, and gold from the Brush Creek, Holy Cross, and Girard Mountain districts, the production of Eagle County was entirely from the Battle Mountain (Red Cliff) district. The value of the output of zinc alone was $1,381,577. The county again surpassed

[1] For discussion of geology see Cross, Whitman, and Spencer, A. C., Geology of the Rico Mountains, Colo.: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 2, pp. 7–165, 1900; and Ransome, F. L., The ore deposits of the Rico Mountains, Colo.: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, pp. 229–398, 1901.

[2] For discussion of treatment of vanadium ores see Moore, R. B., and Kithil, K. L., A preliminary report on uranium and vanadium: U. S. Bur. Mines Bull. 70, p. 74, 1914.

Summit County in yield of zinc, maintaining second place to Lake County.

Battle Mountain (Red Cliff)[1] *district.*—The Red Cliff district in 1915 produced 73,911 tons of ore, yielding $95,135 in gold, 155,323 ounces of silver, 57,343 pounds of copper, 1,389,043 pounds of lead, 11,141,750 pounds of zinc, the total value being $1,630,781, as compared with $539,650 in 1914.

A greatly increased output of lead-zinc ore was mined and milled from the Iron Mask mine in 1915. The output of the mill[2] was zinc, lead, and iron-manganese concentrates. In July, 1915, this mine and mill were taken over by the Empire Zinc Co., which had already purchased several other properties in the district. Lessees on the Bleak House (or Wilkesbarre) mine shipped lead ore to lead smelters and zinc-lead-silver ore to the concentration and flotation plant at Leadville. From the Black Iron mine lead oxidized ores, zinc oxidized ores, and lead-zinc sulphide ores were shipped. Other important mines from which ores were shipped were the Ground Hog, Mabel, Tip-Top, Tram, and Wyoming Valley.

Eagle or Brush Creek district.—Shipments were resumed from this district in 1915, and an appreciable quantity of high-grade silver ore was shipped from the Lady Belle and North Dakota mines.

Girard Mountain district.—A small quantity of silver-copper-gold ore was shipped from the California mine.

Holy Cross district.—Small shipments of silver ore were made from the Eighty-Four mine.

EL PASO COUNTY.

Blair Athol district.—No work was done on the copper deposits in sandstone at Blair Athol, about 6 miles north of Colorado City, from which shipments had been made in 1913 and 1914.

FREMONT COUNTY.[3]

From 4 mines in Fremont County in 1915 there were sold or treated 1,600 tons of ore, yielding $674 in gold, 3,168 ounces of silver, 127,303 pounds of copper, 30,894 pounds of lead, and 228,170 pounds of zinc, with a total value of $54,303, as compared with $27,602 in 1914.

Copper ore was shipped to Omaha from the Green Mountain mine, in the Texas Creek district, near Parkdale. Copper ore was shipped to smelters in Colorado and zinc sulphide ore to smelters in Oklahoma from the Gumaer mine, at Cotopaxi.

GARFIELD COUNTY.

A small output of gold-silver ore was shipped from the Gray Eagle mine near Newcastle.

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[1] For discussion of geology see Means, A. H., Geology and ore deposits of Red Cliff, Colo.: Econ. Geology, vol. 10, No. 1, pp. 1–27, January, 1915. Also Argall, Philip, Siderite and sulphides in Leadville ore deposits: Min. and Sci. Press, July 11, 1914, p. 52 (siderite at Red Cliff).

[2] For description see Hanington, C. H., Colorado Bur. Mines Thirteenth Bienn. Rept., for 1913–14, pp. 78–79, 1914.

[3] Lindgren, Waldemar, Notes on copper in Chaffee, Fremont, and Jefferson counties, Colo.: U. S. Geol. Survey Bull. 340, pp. 166–167, 1908.

GILPIN COUNTY.[1]

Mine production in Gilpin County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	123	52,839	$573,553	145,237	726,579	499,718	12,980	$770,655
1915	90	54,052	562,878	125,665	476,383	591,127	11,000	739,104
Increase or decrease, 1915	−33	+1,213	−10,675	−19,572	−250,196	+91,409	−1,980	−31,551

Notwithstanding the decrease in the number of operating mines in 1915, the production of Gilpin County showed a decrease in total value of only 4 per cent.

The ore sent to amalgamation and concentration mills in Gilpin County (and to amalgamation, cyanidation, and concentration mills at Idaho Springs) increased appreciably, with a considerable increase in gold-silver bullion and precipitates. The ore sent to mills for concentration only and the resulting concentrates also increased materially. The decrease in the production for the year was due entirely to the decrease in the quantity of crude ore sent to smelters.

Operating custom amalgamation and concentration mills in 1915 were the Carr (Most), Polar Star, Smith, and U. P. R. The Iron City concentration mill was operated steadily in 1915, with an increased output. The Frontenac mill was idle. An increased output from the Gunnell mine (Tremont) was mined from the Argo tunnel level and treated at the Argo mill, at Idaho Springs, and ore from the Dyke mine, mined from the tunnel level, was shipped to the sampler and to mills at Idaho Springs.

Almost all the ore of Gilpin County is dry siliceous, but some of the ore carries copper above 2½ per cent, and a small quantity contains lead above 4½ per cent. Concentrating ore in 1915 made practically all dry concentrates, though some lead concentrates and a small lot of zinc concentrates were produced.

Southern districts (Central City, Black Hawk, Nevadaville, Russell Gulch).—The old districts of the main area of Gilpin County are so indefinite that separation of output by districts has been abandoned.

In the near vicinity of Central City producing mines were the Adeline, Bonanza, East Boston, and Troublesome.

Producing mines in the Enterprise district were the Brack Hollow and Coaley.

Producing mines in the district embracing Gunnell Hill and Eureka and Prosser gulches were the Boodle, Buckley, Concrete, Eureka, Gold Collar, and Tremont (Gunnell) group. Only small quantities of ore from the West Whiting and Grand Army mines of the Tremont group were hoisted in Gilpin, a large tonnage being trammed through the Argo tunnel to Idaho Springs.

[1] Bastin, E. S., Preliminary report on the economic geology of Gilpin County, Colo.: U. S. Geol. Survey Bull. 620, pp. 295-323, 1916.
Alsdorf, P. R., Occurrence, geology, and economic value of the pitchblende deposits of Gilpin County, Colo.: Econ. Geology, April-May, 1916, pp. 266-275.

Producing mines in the district embracing the town of Black Hawk and Gregory, Bobtail, and Bates hills were the Bates, Chicago-Carr, Colorado-Carr, Cook, Fisk, Gregory, Gilpin-Orion, Homer, Maine-Hamlet, Nemaha, Running Lode, Senator, Sterling, Togo, and U. P. R.

Producing mines in the district embracing Illinois and Leavenworth gulches and the east portion of Quartz Hill were the Alps (from the dump), Bezant, Calhoun, Delmonico, East Missouri, Ingalls, and Wood. In this district pitchblende has been mined from time to time at the Wood, Kirk, Alps, Calhoun, and German Belcher mines.

Producing mines in the Lake Gulch district were the Justice, Pittsburg, Pittsburg Extension, Meeker, St. Louis, Vivian-Notoway, and West Notoway.

In the vicinity of Nevadaville among the producing mines were the Barnes, Belden, Columbia, First National Kansas, Hubert, Ivanhoe, Phoenix, Burroughs, Pozo-Dyke, Prize, Rome Gardner, San Juan, and West Baker. The Dyke, Phoenix-Ophir, and Prize mines were worked from the Argo tunnel level and the ore was shipped to Idaho Springs, but the contents have been credited to Gilpin County.

In the Quartz Valley district producing mines were the Buckeye, Castle Rock, Gold Cup, Hayseed Tunnel, and Margaret Glennon.

In the Russell Gulch district among producing mines were the Addudell, Argo, Denbigh, Druid, East Notoway, Frontenac, Hampton, Lillian, Old Town, Pewabic, Powers, Richardson, Saratoga, Silver Dollar, Star of the West, Subtreasury, Topeka, and Two-Forty.

Northern districts.—The outlying districts in Gilpin County are the Vermilion district, 4 miles northwest of Central City; Pine district, 7 miles northwest of Central City; Independence and Union districts, 9 miles north of Central City, embracing Perigo and Rollinsville, Lump Gulch, and Moon Gulch sections; Phoenix district, along the north edge of the county, near the Boulder County line; Silver Lake district, 5 miles north of Central City; and Hawkeye district, 7 miles north of Central City and 4 miles east of Apex.

A small production was made from the northern districts in 1915. Several lots of ore from the Mackey mine were treated at the Annie mill, and several test lots of ore from the North Star, in the Vermilion district, were shipped to Black Hawk mills. Silver-lead ore from the Alaska mine, in the Hawkeye district, was shipped to Black Hawk. Ore from the Smuggler mine was treated by amalgamation in the mill on that property. Lessees on the Golden Flint mine operated the mill for a period, the product being gold bullion and gold-silver concentrates. Lessees on the Perigo group operated the mill for a period, with output of gold-silver bullion and gold concentrates.

GRAND COUNTY.

A small yield of placer gold was made in this county.

GUNNISON COUNTY.

Mine production in Gunnison County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	12	6,018	[a]$13,033	[a] 59,036	11,188	317,974	525,000	$86,344
1915	15	6,446	60,197	24,892	9,091	190,000	1,750,944	300,455
Increase or decrease, 1915	+3	+428	+47,164	−34,144	−2,097	−127,974	+1,225,944	+214,111

[a] Includes placer production.

Box Canyon district (*Wuanita Hot Springs*).[1]—There was no output from this district in 1915.

Cebolla district (*Vulcan, Domingo*).[2]—The Good Hope mine, opened by a 720-foot vertical shaft, was unwatered to the 400-foot level, and the shaft and levels were retimbered. Operations commenced in May and several shipments of gold-silver-copper ore were made to smelters. Later in the year lessees took over the mine and commenced the installation of a 40-ton copper matte furnace.

Cochetopa district (*Sillsville*).[1]—No production was made in 1915 in this district.

Elk Mountain district (*Gothic and Crested Butte*).[3]—In and after July a large tonnage of zinc carbonate ore was shipped from the Doctor mine in 1915.

Gold Brick district (*Ohio City*).[1]—Operations at the Carter mine were continued throughout the year. The various claims of the property are opened by several vertical shafts from 50 to 200 feet deep, one 1,135-foot vertical 4-compartment upraise, 6,771 feet of tunnels, and several thousand feet of drifts. The amalgamation and concentration mill[4] was operated continuously up to October 21. Several shipments of lead ore were made from the Gold Link mine, and small shipments of ore were made from the Granite Mountain and Hill Top mines.

Quartz Creek district (*Pitkin*).[1]—A car of silver-lead ore was shipped from the Fairview mine.

Rock Creek district (*Marble*).[5]—No production was made from this district.

Tin Cup district.[1]—Several cars of zinc sulphide ore were shipped from the Forest Hill mine, which is opened by a 360-foot vertical shaft and 5,000 feet of drifts. There is a concentration mill of 40 tons daily capacity on the property. A small shipment of gold-silver

[1] For discussion of geology see Hill, J. M., Notes on the economic geology of southeastern Gunnison County, Colo.: U. S. Geol. Survey Bull. 380, pp. 21–40, 1909.

[2] Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 380, p. 273, 1909; U. S. Geol. Survey Bull. 427, p. 150, 1910. Leith, C. K., Iron ores of the western United States and British Columbia: U. S. Geol. Survey Bull. 285, p. 197, 1906.

[3] Harder, E. C., op. cit., pp. 188–198. Emmons, S. F., Cross, Whitman, and Eldridge, G. H., U. S. Geol. Survey Geol. Atlas, Anthracite-Crested Butte folio (No. 9), 1894.

[4] For description see Carter, C. M., Colorado Bur. Mines Thirteenth Bienn. Rept., for 1913–14, p. 96, 1914.

[5] Emmons, S. F., Cross, Whitman, and Eldridge, G. H., U. S. Geol. Survey Geol. Atlas, Anthracite-Crested Butte folio (No. 9), 1894. (Covers merely extreme source of Rock Creek, and geology discussed only in general way.)

ore was made from the Gold Bug mine. The Tin Cup Gold Dredging Co.'s dredge, on Willow Creek, near Tin Cup, was not operated during the year.

Tomichi district (Whitepine).[1]—Shipments of lead-zinc-silver ore were made from the Morning Star mine, and small shipments were made of lead-copper ore from the Silver Spar mine, and of lead-zinc ore from the Maid of Erin-Silver Pick group.

HINSDALE COUNTY.[2]

Hinsdale County produced in 1915, from 11 mines, 488 tons of ore, yielding $737 in gold; 9,621 ounces of silver, valued at $4,878; 9,114 pounds of copper, valued at $1,595; and 266,128 pounds of lead, valued at $12,508, a total value of $19,718, against $5,978 in 1914.

Galena district.—A small shipment of silver-copper ore was made to the Wanakah smelter from the Excelsior mine. A car of lead-silver ore from the Highland Chief, several cars of lead-silver ore from the Independence, and a small lot of silver-lead ore from the Logan mine, were made to lead plants.

Lake district.—Small lots of ore were shipped from the Belle of the West, California, Cora-Sulphuret, Fannie Fern, and Sacramento mines. A small lot of silver-lead ore was shipped from the Golden Fleece property by lessees, who are preparing to erect a 100-ton mill equipped with Huntington mills, Wilfley tables, and flotation cells for the treatment of the dump ore.

LAKE COUNTY.

PRODUCTION.

Mine production in Lake County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.		Silver.	Copper.	Lead.	Zinc.	Total value.
			Placer.	Deep.					
		Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	96	547,463	.....	$1,571,451	3,810,830	2,382,910	26,784,615	78,763,334	$9,057,297
1915	101	481,620	$69,009	2,177,143	[a] 2,571,002	1,803,423	20,957,404	72,493,178	13,839,401
Increase or decrease, 1915...	+5	−65,843	+69,009	+605,692	−1,239,828	−579,487	−5,827,211	−6,270,156	+4,782,104

[a] Includes placer production.

The total value of the production of Lake County in 1915 was the largest since 1883, and again surpassed that of Teller County—something which it had done in the period 1896–1915 only once before,

[1] For discussion of geology see Crawford, R. D., Geology and ore deposits of the Monarch and Tomichi districts, Colo.: Colorado Geol. Survey Bull. 4, 1913. Hill, J. M., op. cit. Harder, E. C., op. cit. Leith, C. K., op. cit.

[2] For discussion of geology see Irving, J. D., Ore deposits in the vicinity of Lake City, Colo.: U. S. Geol. Survey Bull. 260, pp. 78–84, 1905; Ore deposits of the Ouray district, Colo.: U. S. Geol. Survey Bull. 260, pp. 50–77, 1905. Irving, J. D., and Bancroft, Howland, Geology and ore deposits near Lake City, Colo.: U. S. Geol. Survey Bull. 478, 128 pp., 1911. Larsen, E. S., The economic geology of Carson Camp, Hinsdale County, Colo.: U. S. Geol. Survey Bull. 470, pp. 30–38, 1911. Woolsey, L. H., Lake Fork extension of the Silverton mining area, Colorado: U. S. Geol. Survey Bull. 315, pp. 26–30, 1907.

in 1912. However, Lake County showed a decrease in quantity of ore shipped or treated, following Teller and San Miguel. As seen by the classification of Leadville ores, there was a decided decrease in the quantity of both lead oxidized and lead sulphide ores, but a very considerable increase in the quantity of siliceous oxidized ores shipped; siliceous ores showed an appreciable increase in average content of gold, with a decrease in silver. Though the production of zinc in this county declined 6,270,156 pounds in quantity, the value for 1915 exceeded that for 1914 by $4,972,224. This county was again first in the production of silver, copper, lead, and zinc; in the production of gold it was second only to Teller County, surpassing San Miguel County for the first time since 1903.

Of the State total, Lake County produced 10 per cent of the gold, 35 per cent of the silver, 25 per cent of the copper, 30 per cent of the lead, and 69 per cent of the zinc.

For the first time since placer mining was abandoned in California Gulch, Lake County produced an appreciable quantity of placer gold through the operation of the Derry Ranch dredge, on Arkansas River, 12 miles below Leadville, with a yield of $69,009 in gold and 1,059 ounces of silver.

Lake County includes the Leadville, St. Kevin or Sugar Loaf, Twin Lakes, Lackawanna Gulch, Big English Gulch, Weston Pass, and the Arkansas River placer districts.

LEADVILLE (CALIFORNIA) DISTRICT.[1]

GENERAL FEATURES.

Of a total of 481,620 tons of ore mined in 1915 in this county, 470,808 tons were from the Leadville district. The yield was $2,003,866 in gold, 2,389,371 ounces of silver, 1,782,235 pounds of copper, 20,808,407 pounds of lead, and 72,424,873 pounds of zinc, with a total value of $13,485,847, out of a county total production of $13,839,401. As compared with 1914, this output shows a decrease of 61,894 tons of ore, an increase of $558,229 in gold, a decrease of 1,234,468 ounces of silver, a decrease of 588,081 pounds of copper, a decrease of 5,855,337 pounds of lead, and a decrease of 6,388,461 pounds of zinc.

The output of zinc carbonate ore decreased from 113,881 tons of 24.3 per cent zinc in 1914 to 82,592 tons of 22.48 per cent zinc in 1915. The zinc sulphide ores sold or treated at Leadville increased from 111,947 tons of 21.2 per cent zinc in 1914 to 136,555 tons of 22.09 per cent in 1915. The production of iron pyrites showed a small decrease in quantity but an increase of 20,000 ounces of gold and a decrease of 780,000 ounces of silver. Iron fluxing ore and iron-manganese ore used for fluxing purposes decreased heavily. (There was, however, a heavy increase in shipments of iron-manganese ore for use in the manufacture of spiegeleisen.) The content of gold in siliceous oxide ores more than doubled, while the content of silver decreased slightly. Copper oxidized ores, which amounted to only

[1] For discussion of geology see Emmons, S. F., Geology and mining industry of Leadville, Colo.: U. S. Geol. Survey Mon. 12, 1886. Emmons, S. F., and Irving, J. D., The Downtown district of Leadville, Colo.: U. S. Geol. Survey Bull. 320, 1907. Argall, Philip, Siderite and sulphides in Leadville ore deposits: Min. and Sci. Press, July 11 and 25, 1914, pp. 50–54, 128–135. Harder, E. C., Manganese deposits of the United States: U. S. Geol. Survey Bull. 380, p. 273, 1909: U. S. Geol. Survey Bull. 427, pp. 137–143, 1910.

135 tons in 1914, were 3,359 tons in 1915. These ores averaged 6.33 per cent copper and a little gold and silver.

Classification of Leadville ores in 1915.

Character.	Quantity.	Percentage.
Sulphide:	*Short tons.*	
Zinc-iron-lead (zinc blende: pyrite and galena)	136,555	29
Iron (pyrite with a little gold, silver, copper, and lead, and some zinc blende) [a]	161,677	
Iron (pyrite with a little gold, silver, copper, and lead over 4½ per cent dry lead, with some zinc blende) [a]	1,802	35
Iron (pyrite with a little gold, silver, lead, and copper over 2½ per cent dry copper)	1,627	
Total sulphide	301,661	64
Oxide:		
Lead	16,002	3
Copper [b]	3,359	1
Iron flux	5,699	1
Iron-manganese (silver and some lead) flux	16,761	4
Siliceous [c]	44,734	9
Zinc carbonate silicate	82,592	18
Total oxide	169,147	36
Grand total	470,808	100

Character.	Quantity.	Recovered contents.				
		Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Sulphide:						
Zinc-iron-lead	136,555	[d] 1,595.41	[d] 404,396	[d] 6,008	[d] 12,856,824	[e]
Iron pyrites	161,677	51,716.79	1,560,191	1,092,425	3,707,810	.....
Lead sulphide	1,802	1,567.04	32,154	13,423	451,203	.....
Copper sulphide	1,627	539.74	51,707	145,783	10,131	.....
Oxide:						
Lead	16,002	4,497.76	87,933	38,740	2,649,869	.....
Copper	3,359	24.90	5,252	425,088	.....	.....
Iron flux	5,699	539.55	3,992	556	514	.....
Iron-manganese flux	16,761	95.88	91,951	.....	403,242	.....
Siliceous	44,734	32,181.21	150,257	60,212	728,814	.....
Zinc	82,592	.....	.....	.....	.....	[e]
Metallics (sulphide and oxide)	.....	4,178.75	1,538	.....	.....	.....
	470,808	96,937.03	2,389,371	1,782,235	20,808,407	72,424,873

[a] The greater part of the iron pyrite ore carries iron in excess of silica and also high silver but low gold content; a large quantity (particularly in 1915) of iron pyrite ore (from Breece Hill mines) carries silica in great excess over iron and high gold but low silver content. Some of the iron pyrite ore approaches the zinc-iron-lead classification (when zinc market gives higher returns for sale as lead-zinc sulphide than as lead sulphide to lead smelters) and vice versa. (Note only 1,802 tons of iron pyrite carrying over 4½ per cent lead in 1915, as against 17,100 tons in 1914.)

[b] The high price of copper during 1915 stimulated the sale of this class of ore.

[c] All the siliceous oxide ore is also dry. The greater part of this siliceous oxide ore carries a heavy excess of silica over iron; a small part carries iron and silica in equal quantities. Metallic gold, in quantity 4,178.75 fine ounces, valued at $86,382, and 1,538 ounces of silver, came from less than a ton of ore, from siliceous oxide and sulphide ore bodies.

[d] Recovered as lead and iron concentrates and in zinc residues.

[e] Zinc in terms of recovered spelter and as zinc in zinc oxide.

Classification of Leadville ores in 1915—Continued.

Character.	Average.				
	Gold.	Silver.	Copper.	Lead.	Zinc.
	Ounces per ton.	*Ounces per ton.*	*Per cent.*	*Per cent.*	*Per cent.*
Sulphide:					
Zinc-iron-lead	[a] 0.020	[a] 5.00	(a)	[a] 8.65	[a] 22.00
Iron pyrites	.320	9.65	0.34	1.15	.....
Lead sulphide	.870	17.84	.37	12.52	.....
Copper sulphide	.332	31.78	4.48	.31	.....
Oxide:					
Lead	.281	5.50	.12	8.28	.....
Copper	.007	1.56	6.33	.....	.....
Iron flux	.095	.70	.....	.....	.....
Iron-manganese flux	.006	5.49	.....	1.20	.....
Siliceous	.719	3.36	.07	.81	.....
Zinc	.....	.....	.....	.....	[b] 22.48
Metallics (sulphide and oxide)	.....	.....	.....	.....	.....
	.....	.....	.....	.....	.....

Character.	Recovered contents.					
	Quantity.	Gold.	Silver.	Copper.	Lead.	Zinc.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Dry, iron, and siliceous ores [c]	228,871	88,712.18	1,807,929	1,153,193	4,830,377	.....
Copper ores [d]	4,986	564.64	56,959	570,871	10,131	.....
Lead ores [e]	17,804	6,064.80	120,087	52,163	3,101,075	.....
Zinc ores [f]	91,346	.....	21,870	.....	265,696	34,657,585
Lead-zinc ores [g]	127,801	1,595.41	382,526	6,008	12,591,128	37,767,288
	470,808	96,937.03	2,389,371	1,782,235	20,808,407	72,424,873

[a] Average assay crude ore, mostly milled. (Lead wet assay.)
[b] Average assay actual content. All to zinc smelters.
[c] Includes siliceous oxide, iron, and iron manganese (silver), largest part of iron pyrite. Smelting ores. Also includes metallics.
[d] Sulphide and oxide. Smelting ores.
[e] Sulphide and oxide lead ores. Smelting ores.
[f] Sulphide and carbonate. To smelters.
[g] Sulphides. Greater part to magnetic separating mills.

The course of treatment of Leadville ores, from mine mouth to market, was shown graphically in Mineral Resources for 1911, part 1, page 547, figure 1. With the exception of the quantity of ore, the flow sheet for 1911 applies for 1915.

During 1915 the 50-ton zinc oxide plant completed and operated for a short time only in 1914 was successfully operated on low-grade zinc carbonate ores. The Leadville district concentration mill, which had been remodeled and the Mineral Separation Co.'s flotation process added, was operated steadily on low-grade sulphide ores from various Leadville mines and dumps and from Red Cliff.

The water in the Downtown mines was lowered by electric pumps to nearly 700 feet at the Penrose shaft. In February, 1916, negotiations begun in the fall of 1915 for the purchase of a group of claims on Fryer Hill were consummated by the U .S. Smelting, Refining & Mining Co. and electric pumps were installed at the Harvard shaft.

MINES REVIEW.

California Gulch, Iron Hill, Breece Hill mines as opened by the Yak tunnel.—Of the mines operated by the Yak Co. through the Yak tunnel, the bulk of the ore continued to come from the property of the Cord Mining Co. (Minnie Lee claim). Besides the operations of the Yak Co. and its auxiliary company, the Leadville Exploration & Mining Co., there were shipments of ore by lessees from other mines controlled and developed by the Yak Co. Other mines from which ore was shipped were the Colonel Sellers Fraction, Diamond, Dolly B., Fortune, Golden Rod, Habendum, Logan, Malvina, M. N. Fraction, Polaris, Resurrection, Rubie, Sedalia, Sierra Nevada, South Cord, Tenderfoot, Vega, and White Cap. The bulk of the ore was iron sulphide, which was shipped to lead smelters in Colorado. Zinc-lead sulphide ore went to concentrating plants at Canon City and Denver and to smelters in Kansas, Oklahoma, Wisconsin, Illinois, Ohio, and Pennsylvania. Zinc carbonate ores were shipped from the Dolly B., Polaris, Minnie Lee, and White Cap. A large quantity of lead oxidized ore from the Dolly B., gold-silver oxidized ore and sulphide ore from the Vega, lead oxidized ore from the Polaris, gold-silver oxidized ores from the Diamond and Logan mines, and oxidized and sulphide ores from the Malvina mine were shipped to lead smelters. Large shipments of zinc-lead sulphide ore were made from the Rubie mine to zinc smelters, to lead-zinc concentrating plants, and to plants for the manufacture of sulphuric acid. The magnetic separation plant at the mouth of the Yak tunnel remained idle, and no shipments of the old dump of iron concentrates were made during the year.

Iron Hill.—According to the annual report of the Iron Silver Mining Co. for the year ended December 31, 1915, the yield was as follows:

Output of Moyer, Tucson, and Blind Tom mines, Leadville, in short tons (wet weight).

Class of ore.	Moyer.	Tucson.	Blind Tom.	Lessees.	Total.
Zinc-lead sulphide	6,950	15,756	.....	.....	22,706
Low-grade zinc-lead sulphide	391	.....	.....	.....	391
Lead sulphide	132	.....	.....	.....	132
Iron sulphide	3,569	.....	.....	.....	3,569
Lead carbonate	.....	288	.....	1,201	1,489
Zinc sulphide	5,346	.....	.....	.....	5,346
Siliceous sulphide	86	137	.....	.....	223
Copper sulphide	.....	328	.....	.....	328
Iron oxide	.....	.....	662	391	1,053
Zinc carbonate	.....	.....	287	5,050	5,337
Copper-zinc-lead sulphide	.....	285	.....	.....	285
	16,474	16,794	949	6,642	40,859

NOTE.—Metals contained in these various ores amounted to 575 ounces of gold, 59,565 ounces of silver, 4,205,616 pounds of lead, 33,694 pounds of copper, and 16,674,848 pounds of zinc.

Lead-zinc sulphide ore was shipped from the A. Y. and Minnie mine; large shipments were made of lead-iron and lead-zinc sulphides from the Colonel Sellers mine and from the Louisville mine, and also of lead oxidized ore from the Gilt Edge mine. Lead oxidized ore and iron sulphide ores were shipped from the Adelaide mine on North Iron Hill, iron sulphide from the Humboldt mine, and zinc carbonate from the Smuggler mine.

Breece Hill.—Breece Hill and South Evans Gulch embrace the chief mines of the gold belt.

Lessees on the property of the Ibex Mining Co. continued to ship iron pyrite, copper and lead oxidized, lead sulphide, lead-zinc sulphide, and zinc carbonate ores, as well as considerable metallic gold. Small quantities of iron sulphide were shipped from the Garbutt and Mary Alsberg. A large quantity of siliceous oxidized ore and pyritic ore containing a very good content of gold but only a small quantity of silver was shipped from the Nonie mine. Metallic gold was sent to the mint, and iron sulphide and zinc carbonate ores were shipped in increased quantities from the St. Louis tunnel to smelters. A considerable quantity of hematite fluxing ore and siliceous ore was shipped from the Breece mine; siliceous oxidized ore from the Big Four, Big Six, Great Hopes, Little Bob, Louise, Peggy, McCullum, President, and Robert Burns; zinc carbonate from the Eliza, Highland Chief, and Rattling Jack; and lead oxidized and zinc carbonate ores from the Elk were shipped to smelters.

South Evans Gulch-Little Ellen Hill.—The ores of this vicinity carry an appreciable gold and silver content. Lead sulphide, lead-zinc sulphide, and lead oxidized ores were shipped from the New Monarch mine, and lead oxidized, lead sulphide, siliceous oxidized, and sulphide ores were shipped from the Valley mine. Lead oxidized and zinc carbonate ores were shipped from the Little Ellen mine.

Carbonate Hill.—The bulk of the zinc carbonate at Leadville came from mines on Carbonate Hill. Large shipments were made from the Big Chief, Castle View, Evalyn, Maid of Erin, Wolftone, and other mines of the Western Mining Co. through the Wolftone shaft, and from the Star Consolidated mines. Iron-manganese and lead oxidized ores were also shipped from the Star mines, as well as considerable iron-manganese ore to the steel plant at Pueblo. Lead

oxidized and iron-manganese ores were shipped from the Star of the West mine. Iron-manganese ore was shipped from the Castle View and Evalyn mines. Lead-zinc ore from the Adams dump was shipped to spelter plants, and lead-zinc middlings from the Adams mill dump were treated at the Pingrey mill.

Fryer Hill.—Iron-manganese ore was shipped from the All Right, Climax, Dunkin, Gambetta, Jason, Matchless, Seneca, and Shamrock mines; iron-manganese, lead oxidized, and zinc carbonate ores from the Little Chief; siliceous ore from the North Side; and iron-manganese and zinc carbonate ores from the May Queen. Lead sulphide and lead-zinc sulphide ores were shipped from the Denver City mine. Lead-zinc sulphide ores in considerable quantity were shipped from the Result and Forest City mines of the Small Hopes-Boreel Co. Lead-zinc sulphide ores were shipped from the Gambetta mine.

Printer Boy Hill.—Siliceous oxidized, lead oxidized, zinc carbonate ores, and some metallic gold were shipped from the Lillian mine. Siliceous oxidized ore was shipped from the Lovejoy mine, siliceous oxidized ore from the Reveille mine and from the Ben Franklin.

Rock Hill.—Lead oxidized ore, carrying considerable iron and manganese, and zinc carbonate ores were shipped from the La Plata mines and iron-manganese ore from the Nisi Prius.

Iowa Gulch.—Lead sulphide ore from the First National and iron-manganese ore from the Doris mine were shipped.

Downtown district.—During 1914 the Down Town Mines Co. effected the consolidation of a large group of mines on Lower Carbonate Hill including a portion of the area under the city of Leadville. At the close of the year 1914 this consolidation had progressed to the point of making preparations at the Penrose shaft for the installation of electric pumps, and the work of unwatering was begun on May 8, 1915, the water level at the Penrose then being 238 feet below the collar of the shaft. At the close of the year 1915 the water was lowered at the Penrose mine to nearly 700 feet. The Penrose shaft has a depth of 900 feet, and the unwatering to the bottom of the shaft was completed on June 13, 1916. The principal properties affected by this consolidation are the Coronado, Midas, Niles-Augusta, Gray Eagle and Pocahontas, Stars, Weldon, Bon Air, Bohn, P. O. S., Midland, Alice, Hibschle, Bison, and others. Up to the end of the year 1915 this unwatering apparently had not affected the water in the Wolftone and other shafts on Carbonate Hill to any great extent.

OTHER DISTRICTS.

St. Kevin-Independence (Sugar Loaf) district.—Along the base of the Sawatch Range, including St. Kevin and Sugar Loaf Mountain, is a mineralized region, from which ore has been shipped since the early days of Lake County. In 1915 siliceous oxidized and sulphide silver-gold ores were shipped from the Dinero, siliceous oxidized ore from the Sugar Loaf Co. mines, and gold-silver ore from the Jimmie Swisher mine. A considerable quantity of silver-lead-zinc sulphide ore from the Carleton-Griffin mine was shipped to the River Smelting & Refining Co. at Florence.

Twin Lakes and Lackawanna Gulch districts.—A small lot of gold ore was shipped from the Belle of Granite mine. The Mount

Champion mine, in Lackawanna Gulch, was operated continuously and the 100-ton amalgamation and concentration mill[1] was operated during the last six months of the year. A considerable quantity of very high grade gold ore was shipped from the Lackawanna Belle-Eureka-Saturday Night group. Gold-silver ore was shipped from the Bengal Tiger-Gordon group, and the old mill on this property was remodeled and operated for a short period.

Weston Pass district.—During December, 1915, one car of zinc carbonate ore of good grade was shipped from the Ruby mine, at the head of Weston Gulch. Shipments continued from this district during the early months of 1916.

Arkansas Valley dredge district.—At the mouth of Box Creek, 12 miles from Leadville, a dredge removed from near York, Mont., was installed during the summer and was operated for 70 days. According to the public report[2] of the manager of this dredge, in the two months that the dredge was run it handled 148,000 yards, averaging about 47½ cents per yard, or about 15 per cent above the estimates made from data derived from drill holes. The operating expenses for the two months were $3,350 and $3,600, the increase for the last month being due to ice in the pond. The output of gold-silver bullion was $69,292.[3] The average finenesses of the bullion after melting were, respectively, $0.750 for gold and $0.238 for silver.

LA PLATA COUNTY.

Mine production in La Plata County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	
1914	27	5,083	$126,498	60,244	26,038	11,410	$163,721
1915	25	2,952	71,530	46,369	4,114	23,362	96,857
Increase or decrease, 1915	−2	−2,131	−54,968	−13,875	−21,924	+11,952	−66,864

With the exception of the output of some gold bars and retorts from high-grade specimens, all the ore was shipped to smelters. The average assay per ton of the ore shipped in 1915 was 1.1294 ounces or $23.35 in gold, and 15.71 ounces of silver, as compared with $24.89 in gold and 11.85 ounces of silver in 1914.

California[4] *(La Plata) district.*—The mines of this district are located in the La Plata Mountains, in the drainage basin of La Plata River, centering around the town of La Plata, 10 miles from Hesperus, the shipping point on the Rio Grande Southern Railroad.

The Valley View, May Day, Incas, Tomahawk, Jumbo, and Lucky Four were the principal producing gold-silver mines in 1915. Other producing mines were the Belle, Big Dipper, Butterfly, Crown Dia-

[1] For description see Becker, J. A., Colorado State Bur. Mines Thirteenth Bienn. Rept., 1913–14, p. 95, 1914.
[2] Min. Mag. (London), January, 1916, p. 36.
[3] Min. and Sci. Press, Apr. 22, 1916, p. 608.
[4] For discussion of geology see Cross, Whitman, and others, U. S. Geol. Survey Geol. Atlas, La Plata folio (No. 60), 1899. Emmons, W. H., The Neglected mine and near-by properties, Colo.: U. S. Geol. Survey Bull. 260, pp. 121–127, 1905.

mond, Duke, Durango Girl, Gold Coin, Jenny Lind, Little Nona, Little La Plata, May Rose, Montezuma, Gold Reef, New York, Puzzle, Volcanic, and Western Belle.

The west slope of the west ridge of the La Plata Mountains, in Montezuma County, is a continuation of the La Plata district, from which a small lot of gold-silver ore was shipped from the Gold Dollar mine. Development work was continued on the property of the Doyle Consolidated Mining Co.

Cave Basin district.—This district, from which a small yield was first made in 1913, is located in the San Juan National Forest, and advices from the United States Forest Service indicate that the mineralized area lies about 20 miles north and east of Bayfield, in La Plata County, near the La Plata-Hinsdale county line, between Vallecito and Pine rivers, approximately in secs. 1, 2, 11, and 12, T. 37 N., R 6 W., with a center on Mount Rundlett, and extends northward into T. 38 N. The altitude is from 9,500 to 11,000 feet. The southwest corner of the San Cristobal quadrangle of the United States Geological Survey includes a portion of the district.

A small lot of copper-lead-silver ore was shipped in 1915 from the Holbrook claim.

MESA COUNTY.

In the Sinbad Valley some development work was done on the Pyramid mine. There is a 100-ton leaching plant on the property.

In the Unaweep district[1] some development work was done on the Super-Six, on the Trumbull, and on the Nancy Hanks mine.

MINERAL COUNTY.

Mine production in Mineral County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	9	27,952	$19,304	615,734	32,586	1,401,795	.....	$418,809
1915	9	28,071	33,039	291,807	8,943	2,382,128	85,984	305,172
Increase or decrease, 1915	.....	+119	+13,735	−323,927	−23,643	+980,333	+85,984	−113,637

Creede district.[2]—All the producing mines in Mineral County are included in the Creede district, except one mine situated 10 miles northwest of Creede, which produced considerable silver-gold ore during the years 1912–14, inclusive, but none in 1915.

After an idleness of more than a year, the Humphrey mill was operated continuously after February, 1915, producing a considerable quantity of lead concentrates and several cars of lead-zinc concentrates. None of the other mills in the district were operated, the

[1] For discussion of geology see Butler, B. S., Notes on the Unaweep copper district, Colo.: U. S. Geol. Survey Bull. 580, pp. 19–23, 1914. Emmons, S. F., Copper in the "Red Beds" of the Colorado Plateau region: U. S. Geol. Survey Bull. 260, p. 227, 1905.

[2] For discussion of the geology of the district see Emmons, W. H., and Larsen, E. S., A preliminary report on the geology and ore deposits of Creede, Colo.: U. S. Geol. Survey Bull. 530, pp. 42–65, 1913.

remainder of the production being from lead and dry silver ores shipped to smelters. The smelting ore shipped decreased from 27,952 tons in 1914 to 10,864 tons in 1915.

The producing mines at Creede were the Alpha, Amethyst, Bachelor, Commodore, New York-Last Chance-Volunteer, Park-Regent, Holy Moses, Molly S., and Nelson. The Equity mine, 10 miles northwest of Creede, on the Continental Divide, was idle.

MOFFAT COUNTY.[1]

Placer mines in Moffat County in 1915 produced $2,613 in gold and 6 ounces of silver, as compared with $4,436 in gold and 11 ounces of silver in 1914.

Craig district.—Some gold was taken from the Harkins placer, near Craig.

Fourmile district (near Baggs, Wyo.).—Producing placer mines in this district were the Homestake, Nelson, and Timberlake.

Lay district.—Some development work and testing of gravels was done in this district in 1915.

MONTEZUMA COUNTY.

See California district, La Plata County.

MONTROSE COUNTY.[2]

Several cars of copper ore were shipped from the Cliff Dwellers mine, near Uranium, 11 miles from Paradox. Some placer gold was recovered by sluicing near Uranium.

OURAY COUNTY.[3]

Mine production in Ouray County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	37	105,560	$1,211,993	594,289	854,038	2,119,564	44,608	$1,739,160
1915	38	103,258	1,118,016	576,621	863,851	1,990,681	7,282	1,656,002
Increase or decrease, 1915.	+1	−2,302	−93,977	−17,668	+9,813	−128,883	−37,326	−83,158

[1] White, C. A., On the geology and physiography of a portion of northwestern Colorado and adjacent parts of Utah and Wyoming: U. S. Geol. Survey Ninth Ann. Rept., p. 691, 1889. Gale, H. S., Gold placers near Lay, Routt County, Colo.: U. S. Geol. Survey Bull. 340, pp. 84–85, 1908; Carnotite and associated minerals in western Routt County, Colo.: Idem, pp. 257–262.

[2] Boutwell, J. M., Vanadium and uranium in Utah: U. S. Geol. Survey Bull. 260, pp. 202–203, 1905. Hillebrand, W. F., and Ransome, F. L., On carnotite and associated vanadiferous minerals in western Colorado: U. S. Geol. Survey Bull. 262, pp. 14–16, 1905. Emmons, W. H., The Cashin mine, Montrose County, Colo.: U. S. Geol. Survey Bull. 285, pp. 125–128, 1906.

[3] For discussion of geology see Cross, Whitman, and Howe, Ernest, U. S. Geol. Survey Geol. Atlas, Ouray folio (No. 153), 1907; Silverton folio (No. 120), 1905. Irving, J. D., Ore deposits of the Ouray district, Colo.: U. S. Geol. Survey Bull. 260, pp. 50–77, 1905. Ransome, F. L., A report on the economic geology of the Silverton quadrangle, Colo.: U. S. Geol. Survey Bull. 182, pp. 1–165, 1901.

This county continued to rank fourth in gold, but the total value of metal output was less than the value of the production of Summit County and was only slightly more than that of Eagle County, both of which made large increases because of the greatly increased price of zinc.

The Wanakah copper matting plant, at Ouray, was operated on crude ore and concentrates from the Wanakah mine and mill and on numerous small lots of custom ore from Ouray, Gunnison, Hinsdale, San Juan, and Dolores counties.

The ore sold or treated in the county decreased 2,302 tons. Of the 103,258 tons mined, 35,411 tons were treated at amalgamation and cyanidation mills having concentration equipment, and an average per ton of $18.10 in gold and 0.25 ounce silver were recovered as bullion. From this ore sent to amalgamation and cyanidation mills and from 32,064 tons sent to mills for concentration only were produced 9,150 tons of concentrates averaging $36.08 in gold and 40.90 ounces of silver per ton, and also copper and lead, with a total gross value of $69.20 per ton. Crude ore shipped to smelters (35,783 tons) averaged $4.11 in gold and 5.41 ounces of silver per ton, and also copper, lead, and zinc, with a total average gross value per ton of $10.55.

Red Mountain district.—The Red Mountain district in 1915 produced 2,934 tons of ore, yielding $28,231 in gold, 12,864 ounces of silver, 73,269 pounds of copper, and 119,681 pounds of lead, with a total value of $53,200.

For several years past this district has not been very active, the only work for several years being that done by lessees on the mine and mill of the Barstow property. During 1915 work was continued at the Barstow, the mine being operated throughout the year and the mill at short intervals during the summer. In addition, lessees resumed operations at the National Belle mine, long idle, and shipped a large tonnage of copper ore to smelters. Shipments of ore were also made from the Lake, Mono-Baltic, Saratoga, and Snow Flake mines.

Sneffels district.—This is the principal district in Ouray County. In 1915, from 6 mines, there were sold or treated 62,464 tons of ore, from which were recovered $924,818 in gold, 408,150 ounces of silver, 238,468 pounds of copper, and $1,827,341 pounds of lead, with a total value of $1,259,367, as compared with $1,168,555 in 1914, with $1,050,720 in 1913, with $1,104,159 in 1912, and with $2,162,198 in 1911. The ore decreased 706 tons; gold increased $101,879; silver decreased 21,897 ounces; copper decreased 36,391 pounds; and lead was about the same as in 1914.

The Atlas 20-stamp, 8-foot Hardinge pebble mill flotation plant[1] was operated steadily. The Camp Bird mine and a section of its 60-stamp concentration-cyanidation mill were operated throughout the year on a slightly larger quantity of better grade ore than in 1914. The public annual report[2] of the Camp Bird (Ltd.) for the year ended June 30, 1915, says of the Camp Bird mine:

> Operations during this period have been confined to the territory tributary to shaft No. 3, except that a crosscut is being driven north from second level

[1] For description of mill see Carroll, F., Colorado Bur. Mines Thirteenth Bienn. Rept., for 1913–14, p. 71, 1914; Min. and Sci. Press, June 24, 1916, pp. 953–954.

[2] See also Eng. and Min. Jour., Feb. 26, 1916, p. 399; Met. and Chem. Eng., Mar. 1, 1916, pp. 342–343; Min. and Sci. Press, Jan. 15, 1916, p. 109.

west into territory of the company heretofore unexplored at any considerable depth. * * *

It is again to be observed that profit for the period in review is far in excess of the estimated ore reserves, and that there still remains in reserve a profit almost equal to the estimate of one year ago. This condition is largely due to expansion of the hanging-wall ore body above seventh level, augmented by production from the main vein, including the eighth level, none of which at the time was developed, and to the exclusion in the estimates of large "probable ore" tonnage.

It is gratifying to know, notwithstanding operations were carried to greater depth and into narrow stoping widths, that costs show a material reduction as compared with 1914, prominent among which are 12 cents each in ore production and in milling per ton.

There were no interruptions in operations except those due to three holidays. * * *

The earnings for the year are as follows:

Gross	$949,875.51	Increase	$150,608.78
Expenses (except taxes)	354,519.23	Decrease	32,922.85
Net	595,356.28	Increase	183,531.63
Taxes charged	15,048.55	Decrease	1,431.55
Balance after taxes	580,307.73	Increase	184,963.18
Miscellaneous revenue	3,393.01	Increase	1,417.05
Profit at mines and mills (exclusive of depreciation)	583,700.74	Increase	186,380.23

Exclusive of depreciation of equipment the cost is $9.82 per ton. There was in addition $1.60 per ton expended in development work (including the cost of sinking shaft No. 3 a distance of 102 feet to ninth level), as against $1.85 the previous year. As compared with last year there is a net decrease of $0.98 in the cost per ton. * * *

The comparative tonnage treated during the past two years is as follows:

	Ore treated.	Concentrate produced.
	Wet tons.	*Wet tons.*
Year ended June 30, 1915	32,959	6,054
Year ended June 30, 1914	31,381	6,956

There are in the mine at this date 14,800 tons of broken ore and 1,100 tons of unbroken ore that, it is estimated, will yield a profit of $275,000.

During the year there were 28,273 tons of ore broken down in the stopes and development, of which 15,369 tons were delivered to the mills and 12,904 tons temporarily left in the stopes.

From the reserves in stopes and including that temporarily left 17,592 tons were withdrawn (2,260 tons in excess of original estimates), making a total to the mills of (based on measurements) 32,961 tons, or (based on mills' weights) 32,909 tons (wet weight); and there were treated in mills 32,313 tons (dry weight).

	Tons.
On July 1, 1914, there were broken in stopes	17,616
Added during the year	12,904
	30,520
Withdrawn during the year	15,332
Leaving in stopes June 30, 1915, wet weight (or 14,580 tons, dry weight) of ore	15,188

In addition at this date there are 300 tons (wet weight) or 288 tons (dry weight) of ore in mine chutes, making a total in stopes and chutes of 15,488 tons (wet weight) or 14,868 tons (dry weight) of ore.

Thirty-two thousand three hundred and thirteen tons of ore (dry weight) treated yielded $952,288.25, or an average per ton of $29.47, as against $26.19 last year.

Based on 25 stamps dropping, the running time in both mills was 357 days, 7 hours, 6 minutes.

Of the gold in crude ore there was a saving of 96.03 per cent, and a saving of 94.31 per cent in the combined value of gold and silver.

Of the total value extracted there was obtained through—

	This year.	Last year.
	Per cent.	*Per cent.*
Amalgamation	58.48	52.97
Concentration	36.59	42.07
Cyanidation	4.93	4.96

The value of the content compares as follows:

	This year.	Last year.
	Per cent.	*Per cent.*
Gold	91.75	87.49
Silver	6.09	9.01
Lead	1.18	1.67
Copper	.98	1.83

Content and value of ore per ton, recovered, compare with last year as follows:

	Gold.	Silver.	Lead.	Copper.	Total.
Content:	*Ounces.*	*Ounces.*	*Per cent.*	*Per cent.*	
This year	1.333	3.78	1.048	0.167	.....
Last year	1.135	4.27	1.324	.260	.....
Value:					
This year	$27.04	$1.79	$0.35	$0.29	$29.47
Last year	22.91	2.36	.44	.48	26.19

The value of the metallic content of the year's production compares with last year as follows:

	This year.	Last year.	Increase.	Decrease.
Gold	$873,717.23	$700,879.59	$172,837.64	.....
Silver	58,015.18	72,205.79	.....	$14,190.61
Lead	11,190.95	13,378.22	.....	2,187.27
Copper	9,364.89	14,615.52	.....	5,250.63
	952,288.25	801,079.12	151,209.13	.....

There were treated by amalgamation and concentration, the tailing having been passed to cyanide mill, 32,959 tons (wet weight), moisture 1.96 per cent, or 32,313 tons (dry weight) of ore. There was passed to the cyanide mill 26,850 tons of tailing, from which 20,655 tons (dry weight) were separated and treated. There was no impounded tailing treated during the year.

Production of stamp mill.

Gross value recovered		$905,291.71
Expenses:		
Maintenance	$10,569.67	
Other operating	39,329.51	
		49,899.18
Net recovery		855,392.53

Production of cyanide mill.

Gross value recovered		46,996.54
Expenses:		
Maintenance	$2,003.01	
Other operating	26,390.55	
		28,393.56
Net recovery		18,602.98

Total net recovery, $873,995.51.

At a meeting[1] in London on December 21, 1915, future development was planned as follows:

The manager considered that the present showing on the ninth level, coupled with past production of this ore shoot, justified exploring considerably deeper. No. 3 shaft had now reached its limit of depth with the present equipment, and the question of further development of the mine in depth had received the attention of the management and the technical committee. * * * (Their recommendation is) after thorough investigation all available mine openings, consideration history of mine, and study ore occurrence, strongly recommend further extensive development in depth. Recommend low level adit, length 10,700 feet; will be 450 feet below present deepest workings and 800 feet below workings next most important section. Careful estimate of cost exclusive administration will not exceed $200,000, and time about 27 months. Prospects below ninth level for continuance of present shoot most favorable. Only alternative to new adit is to strip No. 3 shaft and provide new equipment. Do not recommend this, as any proposal further extensive development must provide for thorough test western section, which I regard important, and this almost prohibitive through shaft on account heavy water. Adit has every probability cutting other veins. In view of the recommendations, * * * the board instructed * * * to proceed with this tunnel immediately.

In regard to the geological conditions of the proposed work, the Mining Magazine says:[2]

It will be recalled that the adit through which the main workings have their outlet was driven about at the contact, here essentially horizontal, between the San Juan tuffs below and the overlying Silverton series of rhyolites. * * * When the mine was examined for purchase by Camp Bird Limited, rich bodies of ore had been traversed horizontally at the adit level, but their extension above and below was not known. There was much discussion among the examining engineers as to whether the ore shoots were properly to be regarded as elliptical ore bodies having their major axes horizontal or vertical, a most important matter in fixing a safe price for the property. We believe the general consensus of opinion favored regarding the horizontal extension the greater one. Subsequent work has tended to show that the vertical factor was more important than then estimated. Inspection of stope maps now shows ore shoots with the major extension downward, as is normal for ore bodies in such rocks. Several such bodies have been followed below the adit level well down in the San Juan tuffs. Work on one was stopped by a heavy flow of water, but at the No. 3 shaft an ore shoot, barely 20 feet long when first found but lengthening to 250 feet below, has been followed nearly 1,000 feet below the adit. These lower ore bodies in the San Juan are not so rich as were those worked in the Silverton series, but they have yielded a substantial profit despite the high cost of work through internal shafts. It has now been decided that, having plant and staff available, there is too much ore in sight and indicated below the adit

[1] Min. Mag. (London), January, 1916, pp. 25–26, adv. section.
[2] Idem., March, 1916, p. 138.

to warrant abandoning the property without thorough development. A new adit is to be driven from the mill level to drain and prospect the vein at 400 feet below the lowest workings. * * * Even this new adit will not exhaust the possibilities of the property. If driven at the horizon of the mill, it will be (we speak from memory), at least 500 feet above the base of the San Juan series and the highest of the sediments, the Telluride conglomerate.

Some gold-silver ore was shipped from the Bi-Metallist mine, considerable lead-silver ore was shipped from the Cumberland mine, a car of lead-silver ore from the Mountain Top mine, and a car of gold-silver ore from the Wheel of Fortune mine.

Uncompahgre district.—The Uncompahgre district produced in 1915 from 27 mines 37,860 tons, yielding $164,967 in gold, 155,607 ounces of silver, 552,114 pounds of copper, 43,659 pounds of lead, and 7,282 pounds of zinc, with a total value of $343,435, as compared with $521,174 in 1914, $317,942 in 1913, $309,434 in 1912, and $187,802 in 1911.

The Bright Diamond-Iron Clad group, operated by the Wanakah Co., was the principal producing property. A large quantity of pyritic (with some chalcopyrite) gold-silver ore was sent direct to the Wanakah copper matting plant. The company's 20-stamp amalgamation and concentration mill was operated only part of the year, with a greatly reduced output of bullion and concentrates.

Ore from the American-Nettie mine was milled in a 3½-foot Huntington mill having amalgamation and a Wilfley table. Considerable ore was shipped from the mine and dump of the Newsboy property to various smelters and silver ore from the Black Girl and from the Senorita and Wedge mines. Copper-lead ore was shipped from the Wewissa mine. Many small lots of ore from various properties in this district were shipped to the Wanakah plant.

PARK COUNTY.[1]

Mine production in Park County, Colo., in 1914 and 1915.

	Number of producing mines.	Ore.	Gold.		Silver.[a]	Copper.	Lead.	Zinc.	Total value.
			Placer.	Deep.					
		Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	15	1,958	$23,334	$44,151	20,215	8,023	168,154	57,940	$89,244
1915	17	2,820	9,792	149,547	9,227	12,303	190,830	472,992	253,790
Increase or decrease, 1915	+2	+862	−13,542	+105,396	−10,988	+4,280	+22,676	+415,052	+144,546

[a] Includes placer production.

There were 14 producing deep mines and 3 placers in this county in 1915, an increase of 3 deep mines and a decrease of 1 placer. The placer yield was $9,792 in gold and 73 ounces of silver, as compared with $23,334 in gold and 206 ounces of silver in 1914.

Beaver district.—Placer mines in this district were idle.

Buckskin district.—There were several small lots of ore shipped from the Bemrose, Louisville, No End, and Rollins Phillips mines.

[1] For discussion of geology see Patton, H. B., Hoskin, A. J., and Butler, G. M., Geology and ore deposits of the Alma district, Park County, Colo.: Colorado Geol. Survey Bull. 3, 1912.

The amalgamation mill on the Paris mine was operated intermittently, but operations at the mine were continuous, with a small force for 10 months of the year, and several cars of ore were shipped direct to the smelter.

Consolidated Montgomery district.—Small lots of ore were shipped from the Atlantic and Pacific, D. H. Hill, Magnolia, and Our Fritz mines.

Freshwater district (Guffey).—Development work only was done at the Mill Gulch mine in this district.

Horseshoe district.—Lead-silver ore and zinc carbonate ore in increased quantities were shipped from the Chance-Hilltop mine. The Snowstorm placers were operated for a short period only.

Lake George (Pulver) district.—No work was done at the Great Western property.

Mosquito district.—Lessees operating the London mine,[1] at the head of Mosquito Creek, on the ridge between Leadville and Alma, shipped a considerably increased quantity of ore carrying a very appreciable content of gold. A small shipment was made from the Golden Wave mine.

Tarryall district.—The Fortune placers, 4 miles from Como, on Tarryall Creek, were operated for four months by hydraulicking, with an appreciable output of gold bullion, averaging 0.887 gold and 0.111 silver.

PITKIN COUNTY.[2]

Mine production in Pitkin County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	13	118,000	$423	372,886	67,737	23,233,230	145,431	$1,129,151
1915	13	108,579	29	448,915	19,983	19,265,213	214,952	1,163,245
Increase or decrease, 1915	.....	−9,421	−394	+76,029	−47,754	−3,968,017	+69,521	+34,094

Aspen (Roaring Fork) district.—At Aspen are located all the principal producing mines in Pitkin County, nearly all of which were operated by the Smuggler Leasing Co. An increased tonnage of milling ore was sent to the Smuggler 360-ton concentrating mill,[3] but a considerably decreased tonnage of lead ore was shipped direct to smelters. Other producing mines were the Argentum-Juniata, Aspen, Della S., Durant, and Smuggler. Zinc carbonate and sulphide ores were shipped from the Durant mine.

The ore of the district mined during the year 1915 was higher in silver content and lower in lead content than that sold or treated in 1914.

[1] For discussion of geology see Moore, C. J., The London mine, Mosquito district, Colo.: Am. Inst. Min. Eng. Bull. 75, pp. 415–427, March, 1913.

[2] For discussion of geology see Spurr, J. E., Geology of the Aspen mining district, Colo., with Atlas: U. S. Geol. Survey Mon. 31, 260 pp., 1898.

[3] For description of mill see Anderson, C. E., Colorado Bur. Mines Thirteenth Bienn. Rept., for 1913–14, pp. 104–105, 1914.

The Hope Co., a corporation composed of local people, continued to drive steadily its crosscut adit to cut the Little Annie and other mines at depth. During 1915 this adit was extended 1,138 feet, a total length of 5,600 feet.

Ashcroft (Columbia) district.—A car of lead-silver ore was shipped from the dump of the Montezuma-Tam o' Shanter mine.

RIO GRANDE COUNTY.

Summitville district.—Operations at the Bonanza mine resulted in an appreciable output during 1915. (See also Conejos County.)

ROUTT COUNTY.[1]

Hahns Peak district.—Some placer gold was recovered by sluicing in 1915. During the greater part of the year no work was done on the Royal Flush group, but development work was again commenced in November. There is a concentration mill of 400 tons daily capacity on this property.

Slater district.—Assessment work was done on the mines near Slater.

Yarmony district.—At the Copper King claim, which is opened by a 400-foot inclined shaft, a 40-ton mill was in the course of construction. The process to be used at this plant includes crushing, leaching, and electrolysis for the treatment of copper carbonate in sandstone.

SAGUACHE COUNTY.

Mine production in Saguache County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	8	1,488	$16,513	18,293	35,783	534,872	8,941	$52,704
1915	10	692	5,273	11,266	23,360	174,447	44,250	28,759
Increase or decrease, 1915	+2	−796	−11,240	−7,027	−12,423	−360,425	+35,309	−23,945

Baca Grant (Crestone) district.—Small lots of ore were shipped from the Golden Treasure mine and from the Independence mine.

Cochetopa district.—No production was made from the Alaska-Yukon mine.

Iris district.—A car of lead-zinc sulphide ore was shipped from the Denver City mine, at Iris, 16 miles southeast of Gunnison. This property has been idle for many years.

Kerber Creek (Bonanza) district.—The output from this district, the principal producing district in the county, decreased appreciably. Lead sulphide ore was shipped from the Antoro, Elizabeth,

[1] For discussion of geology see George, R. D., and Crawford, R. D., The Hahns Peak region, Routt County, Colo.: Colorado Geol. Survey First Rept. for 1908, pp. 189–229, 1909. Gale, H. S., The Hahns Peak gold field: U. S. Geol. Survey Bull. 285, pp. 28–34, 1906. White, C. A., On the geology and physiography of a portion of northwestern Colorado and adjacent parts of Utah and Wyoming: U. S. Geol. Survey Ninth Ann. Rept., p. 691, 1889.

Minnie Lynch, and St. Louis mines; copper-lead and lead-zinc ores from the Bonanza mine. No work was done on the Rawley mine.

SAN JUAN COUNTY.[1]

Mine production in San Juan County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	29	117,988	$508,477	493,917	825,180	5,199,000	971,177	$1,143,653
1915	42	147,878	583,681	430,637	1,054,463	6,791,596	2,259,226	1,585,894
Increase or decrease, 1915	+13	+29,890	+75,204	—63,280	+229,283	+1,592,596	+1,288 049	+442,241

During 1915 there were treated at amalgamation and cyanidation mills 51,842 tons of ore, with an average recovery per ton in bullion of $1.94 in gold and 0.04 ounce silver; there were also 90,084 tons sent to mills for concentration only, a total of 141,926 tons (96 per cent of all the ore mined), which yielded 20,758 tons of concentrates, averaging $18.62 per ton in gold, 14.83 ounces of silver, and also copper, lead, and zinc, with a total gross value per ton of $59.08.

Crude ore shipped to smelters—5,952 tons—averaged per ton $16.24 in gold and 20.29 ounces silver, and also 1.36 per cent copper and 12.80 per cent lead.

Animas district (including the mines in the vicinity of Silverton and south and east of Animas River from Silverton to Middleton).—The Animas district in 1915 produced 56,013 tons of ore, yielding $212,071 in gold, 239,637 ounces of silver, 535,971 pounds of copper, 2,981,851 pounds of lead, and 9,121 pounds of zinc, with a total value of $568,640, as compared with $621,974 in 1914.

The principal producing mines in the district were the Iowa-Gold Tiger group and the Silver Lake mines. A large quantity of lead sulphide ore from the Iowa-Gold Tiger mine was milled at the company's 100-ton concentration mill, the equipment of which includes jigs, Chilean mills, Wilfley tables, and flotation cells. The Silver Lake mines, under lease, were continuously operated throughout the year. Considerable ore was shipped direct to the Durango smelter, and milling ore was treated at the Iowa-Tiger mill or at the Silver Lake mill. The equipment of the Silver Lake mill consists of rolls, jigs, Chilean mill, Wilfley tables, and flotation cells. Considerable old tailing from the Silver Lake mines was flumed to the Mears-Wilfley mill, to which the flotation process had been added. The Intersection 10-stamp amalgamation and concentration mill was operated from May 1 throughout the year. Lead ore was shipped from the Dives and Shenandoah mines. Other producing mines were the Anti-Periodic, Barbara, Bonner, Kittimac, Little Maud, Mayflower, Mag-

[1] For discussion of geology see Cross, Whitman, Howe, Ernest, and Ransome, F. L., U. S. Geol. Survey Geol. Atlas, Silverton folio (No. 120), 1905. Emmons, W. H., Ore deposits of Bear Creek, near Silverton, Colo.: U. S. Geol. Survey Bull. 285, pp. 25–27, 1906. Ransome, F. L., A report on the economic geology of the Silverton quadrangle, Colo.: U. S. Geol. Survey Bull. 182, pp. 1–265, 1901.

net, North Star, Old Green Mountain, Old Hundred, Pride of the West, Queen City, Primrose, and Ridge.

Eureka district (north of Silverton, including Chattanooga, Gladstone, Animas Forks, and Eureka).—This district in 1915 produced 91,865 short tons of ore, yielding $371,610 in gold, 191,000 ounces of silver, 518,492 pounds of copper, 3,809,745 pounds of lead, and 2,250,105 pounds of zinc, with a total value of $1,017,254, as compared with $521,679 in 1914.

The Sunnyside mine and amalgamation and concentration mills (one 30-stamp and one 10-stamp, including 1 Huff electrostatic separating plant and also flotation machines), were operated steadily and produced gold-silver bullion, lead concentrate, and zinc concentrate. The Gold King concentration mill, with flotation machines for the treatment of slimes, was operated most of the year, and had a large output of concentrates. Several shipments of high-grade gold ore were made direct to the smelter. Lead ore from the Hermes mines was treated at the Frisco mill. The Silver Ledge concentration mill was operated part of 1915, its product being a lead concentrate and a zinc concentrate. Copper ore was shipped from the Congress mine, in the Red Mountain district. Several cars of silver-lead ore were shipped from the Emma mine, in Ice Lake Basin. Silver-gold ore was shipped from the Columbus mine, at Animas Forks. Other producing mines were the Golden Fleece (Lion tunnel), Joe and John, Silver Wing, and Sultana-Senior Warden.

SAN MIGUEL COUNTY.[1]

Mine production in San Miguel County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	25	495,742	$2,114,916	1,280,461	324,105	4,039,769	.....	$3,023,668
1915	25	483,954	2,069,362	1,096,641	562,554	5,240,277	1,040,121	3,099,074
Increase or decrease, 1915	.....	−11,788	−45,554	−183,820	+238,449	+1,200,508	+1,040,121	+75,406

In gross value of production San Miguel County is the principal county in the San Juan region. In 1915 this county yielded second place (after Teller) in the production of gold to Lake County, and in silver it held second place after Lake County. In total gross value of metals produced, San Miguel continued to stand third, with Lake County first, Teller second, Summit fourth, Ouray fifth, and Eagle sixth.

During 1915, of the 483,954 tons mined, there were treated at amalgamation and cyanidation mills (most of which also had concentration equipment) 473,986 tons of ore, or 98 per cent of all the ore mined; and an average per ton of $2.70 in gold and 107 ounces

[1] For discussion of geology see Purington, C. W., Preliminary report on the mining industries of the Telluride quadrangle, Colo.: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 745–850, 1898. Cross, Whitman, and Purington, C. W., U. S. Geol. Survey Geol. Atlas, Telluride folio (No. 57), 1899. Hess, F. L., Notes on the vanadium deposits near Placerville, Colo.: U. S. Geol. Survey Bull. 530, pp. 142–156, 1912.

of silver was saved as bullion or as cyanide precipitate. The gold saved as bullion in 1915 represented 62 per cent of the gold produced in the county, and the silver in the bullion represented 46 per cent of the county's silver output. There were 9,636 tons of ore sent to mills for concentration only, making a total of 483,622 tons milled (99.93 per cent of all the ore mined), which yielded 27,284 tons of concentrates, averaging per ton, $28.77 in gold and 21.31 ounces of silver, and also copper, lead, and zinc, with a total gross value per ton of $56.39, as compared with $47.34 in 1914. Crude ore sent to smelters—332 tons—averaged per ton $7.60 in gold and 21.66 ounces of silver, and 1.01 per cent copper and 21.77 per cent lead.

Upper San Miguel district.—The Upper San Miguel district in 1915 produced 474,851 tons of ore, yielding $2,041,851 in gold, 1,090,219 ounces of silver, 560,606 pounds of copper, 5,193,298 pounds of lead, and 1,040,121 pounds of zinc, with a total value of $3,065,758, as compared with $2,944,971 in 1914.

The three larger companies, the Liberty Bell, the Smuggler Union, and the Tomboy, continued to furnish the greater part of the total output, although some ore from the Black Bear mine was treated at the Smuggler Union mill.

The annual report of the Tomboy Gold Mines Co. (Ltd.) for the year ending June 30, 1915, states:

> One hundred and forty-five thousand eight hundred and fifty-seven tons of ore were treated, yielding $1,027,524, or $7.05 per ton. Expenses amounted to $654,647 and profits were $372,877. The following is a summary of receipts and expenditures:

145,857 dry tons ore milled, yielding bullion worth			$414,114.06
Concentrates worth			537,494.90
Cyanide bullion worth			75,915.43
Dividends from the Tomboy Tramway & Tunnel Co			10,000.80
Boarding house, rents, etc			13,345.52
			1,050,870.08
	Per ton.		
Mining and development expenses	$2.44	$356,041.58	
Milling expenses	.53	77,240.31	
Concentrating expenses (including transportation to railway)	.48	69,650.21	
Water-supply expenses	.09	13,582.65	
Assay-office expenses	.03	4,918.75	
Cyaniding expenses (at $0.90 per ton of tailings treated)	.45	64,984.10	
General expenses	.24	35,037.56	
Taxes and insurance	.23	33,192.26	
Total expenses	4.49		654,647.42
Surplus			396,222.66

Ore reserves in the Argentine group are estimated to contain 185,000 tons, of which 135,000 tons is broken in stopes. The Montana group is estimated to have 350,000 tons, of which 200,000 tons is broken in stopes. No estimate of the grade of this ore is given.

The cyanide plant was started about the middle of December, 1914. From a mechanical point of view it has given satisfaction, but the extraction has been much lower than expected, judging from the preliminary experiments. Operations indicated that the agitators would require a more diluted pulp. This has necessitated the addition of more filter capacity.[1]

[1] See Eng. and Min. Jour., Mar. 11, 1916, p. 481; also Min. Mag. (London), November, 1915, p. 292, and p. 23, advertising section.

For the calendar year 1915 the Tomboy 400-ton 60-stamp amalgamation and concentration mill and 400-ton cyanide plant were operated continuously throughout the year.

The 80-stamp 500-ton cyanidation and concentration mill of the Liberty Bell Co. was operated continuously. The ore is crushed in cyanide solution, agitated, and the contents are recovered by filtration. The concentrate made is roughly cyanided and shipped to the Durango smelter.

According to a report of the operating costs at the Liberty Bell mill,[1]

> The mill has cost, from 1897 to 1913, $345,000. Since 1913 no charge has been made to construction. Of course, part of the cost went into canvas plants which were scrapped, and part represents replacements partly destructive of old work. About 700 horsepower is required for the mill operation.
>
> The recovery in the mill is, in stamp bullion, 1 per cent of gold and no silver; in concentrates, 5 per cent of the gold and 9 per cent of the silver. In miscellaneous cyanide products, including bullion, slag, etc., the recovery is 82 per cent of the gold and 67 per cent of the silver, making a total recovery of 88 per cent of the gold and 76 per cent of the silver. About 600 gallons of water per minute is used, almost solely to dispose of tailings. The ratio of concentration is 58 to 1. The assay of mill heads from 1899 to 1915, inclusive, was $7.89; the tailings, $1.44; the percentage of extraction, 82 per cent. In 1915 the total combined extraction was 85 per cent. The mill and shop employ about 47 men, the shop crew doing some mine and tramway work.

The Smuggler Union mines and 140-stamp 500-ton amalgamation, concentration, and cyanidation mills[2] were operated steadily on ores from the Smuggler Union group and, in addition, on ores from the Black Bear mine. The output of the Black Bear mine up to the beginning of 1915 had never been large, but as a result of the operations in 1915 a very considerable quantity of lead and iron concentrates carrying gold and silver were shipped to lead plants and a large quantity of lead-zinc concentrates were shipped to zinc plants. The 30-stamp amalgamation and concentration mill of the Alta mine was operated at one-third capacity. Lessees on the Ballard group operated the amalgamation mill on the property for a period. A considerable quantity of ore from the Palmyra and Johnnie mines was treated by amalgamation at the Alta mill. Other mines from which a small production was made were the Beatrice, Cimarron, Fairview, Little Bessie, Little Mary, and Snow Drift.

Iron Springs (Ames and Ophir) district.—The Iron Springs district in 1915 produced 9,103 tons of ore, yielding $27,511 in gold, 6,422 ounces of silver, 1,948 pounds of copper, and 46,979 pounds of lead, with a total value of $33,316, as compared with $75,688 in 1914 and with $135,095 in 1913.

There were 10 producing mines in the district. The Butterfly-Terrible mine and mill were operated the greater part of the year by lessees. The Suffolk mill was repaired, and ores from the Suffolk and Yellow Girl mines were treated by amalgamation during the last six months of the year. Gold-silver bullion was shipped to the mint as the result of the treatment of ore from the Charter Oak mine. Other mines from which a small production was made were

[1] Eng. and Min. Jour., July 1, 1916, pp. 3–4; see also Weinig, A. J., The Liberty Bell methods of precipitate refining: Am. Inst. Min. Eng. Bull. 111, pp. 651–662, March, 1916.

[2] For description see Wells, Bulkeley, Colorado Bur. Mines Thirteenth Bienn. Rept., for 1913–14, pp. 98–99, 1914.

the Baltimore, Calumet, Carbonero, Parsons, Pike County, and San Bernardo.

Lower San Miguel (Sawpit and Placerville) district.—No yield was made from this district.

Mount Wilson district.—There was no production from this district.

SUMMIT COUNTY.

Mine production in Summit County, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.		Silver.[a]	Copper.	Lead.	Zinc.	Total value.
			Placers.	Deep.					
		Short tons.			*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	51	22,199	$608,567	$60,043	67,009	7,339	1,565,231	5,111,941	$1,028,395
1915	41	44,602	607,195	72,949	64,223	8,646	1,916,298	8,597,411	1,870,363
Increase or decrease, 1915	−10	+22,403	−1,372	+12,906	−2,786	+1,307	+351,067	+3,485,470	+841,968

[a] Includes placer production.

Dredges[1] and other placer operations yielded $607,195 in gold and 7,487 ounces of silver, valued at $3,796, a total of $610,991, against $608,567 in gold and 7,018 ounces of silver in 1914, and against $386,196 in gold and 4,379 ounces of silver in 1913.

Summit County is the principal placer-producing county in Colorado and is also one of the principal zinc-producing districts. In 1915, notwithstanding a considerable increase in the yield of zinc, this county produced less zinc than Eagle and Lake counties.

Breckenridge district.[2]—The Breckenridge district includes the Bevan, Minnesota, and Union districts, and contains the mines near Breckenridge, on French Gulch, on Blue and Swan rivers, and all the placers in the county. The value of the total output of gold, silver, copper, lead, and zinc from both deep and placer mines was $1,796,637, or 96 per cent of the county yield, and an increase for 1915 of $814,308.

The principal producing mine in the district is the Wellington. The 110-ton wet-concentration mill, with rolls, tables, and flotation cells, and the 55-ton roasting and magnetic separation mill[3] were operated continuously, with a resultant increase in output of lead and zinc concentrates. In the wet mill the lead and part of the zinc are taken out and the silica eliminated. The zinc middling is roasted and the iron taken out in the magnetic mill.

[1] See Revett, B. S., Gold dredging: Colorado Bur. Mines Thirteenth Bienn. Rept., for 1913–14, pp. 128–131, 1914.

[2] For discussion of the geology of the district see Ransome, F. L., Geology and ore deposits of the Breckenridge district, Colo.: U. S. Geol. Survey Prof. Paper 75, 1911.

[3] For description of magnetic plant see Parmelee, H. C., Zinc ore dressing in Colorado: Met. and Chem. Eng., September, 1912, pp. 525–528. Also for description of mills see Henderson, R. M., Colorado Bur. Mines Thirteenth Bienn. Rept., for 1913–14, pp. 106–110, 1914.

The Wellington Mines Co. reports[1] its financial condition for the period from December 1, 1914, to October 1, 1915, as follows:

Concentrate sales—zinc	$438,336.38
Concentrate sales—lead	39,680.52
	478,016.90
Transfer fees	33.40
Interest	1,356.59
Gross income	479,406.89
Mining, milling, and operating expenses	155,777.16
Net income	323,629.73
Balance on hand November 30, 1914	41,224.22
	364,853.95

Several large lots of metallic gold were recovered from pockets in the Dunkin mine and shipped to the Denver Mint. In addition, several cars of very high grade gold ore were shipped direct to the smelter. Lessees on the Country Boy mine in the early part of the year shipped several cars of very high grade zinc ore to smelters in Kansas, and a considerable tonnage of low grade zinc ore to the Pingrey flotation mill at Leadville. A different set of lessees in the latter part of the year erected a small concentrating plant at the mine, increasing the assay of the low grade zinc ore treated, and also shipped ore to the Old Union mill at Breckenridge and to the Pingrey mill at Leadville. Other producing lode mines were the Alice, Carbonate, Eureka, Germania, Gold Dust, Helen Jessie, Ohio, Ouray, Puzzle, and Washington.

All four of the dredges in the district were operated in 1915, with little change in the output as compared with 1914. The Tonopah Placers Co. put 2 of its dredges in operation—1 in March and 1 in May, 1915—and continued to operate them until the end of December, at which time they were closed down on account of the winter weather and for necessary repairs. Two of these dredges are of the Bucyrus open-connected type, with buckets of a capacity of 9½ cubic feet. The other dredge is of the double-lift open-connected type, with buckets of a capacity of 9 cubic feet.

The report of the Tonopah Placers Co. for the fiscal year ending February 29, 1916, appears in the annual statement of the Tonopah Mining Co. of Nevada:

Production of Tonopah Placers Co., fiscal year ending February 29, 1916

Gross value of bullion shipped to mint	$479,017.56
Cost of operations	267,324.57
	211,692.99
Cubic yards dredged	3,242,247
Gold produced ounces	23,034.30
Silver produced do	5,416.10
Value per yard	$0.147
Profit per yard	$0.086
Acres dredged, 1915	53.175
Acres dredged prior to 1915	246.498
Acres undredged	4,782.918
Acres placer ground	5,082.591
Acres lode ground	36.226

[1] Min. and Eng. World, Nov. 20, 1916, p. 815.

The bullion from the Tonopah Co.'s dredges averaged in fineness 0.803 gold and 0.189 silver. The fineness of the bullion produced by the various boats of this company varied, however, being respectively 0.794, 0.824, and 0.749 for dredges Nos. 1, 2, and 3. The French Gulch Dredging Co., or Reiling dredge (Bucyrus type), with buckets of a capacity of 5 cubic feet, was operated for eight months. The bullion from the French Gulch dredge averaged in fineness 0.740 gold and 0.233 silver. The Banner, Bemrose, Sisler, Mekka, and Washington placers were operated by hydraulicking and sluicing.

Consolidated Tenmile district (Frisco, Kokomo, and Robinson).[1]—This district in 1915 from 11 mines produced 1,666 tons of ore, yielding $8,299 in gold, 13,412 ounces of silver, 3,057 pounds of copper, 183,872 pounds of lead, and 8,968 pounds of zinc, with a total value of $25,388, as compared with $13,661 in 1914.

The Robinson mine and magnetic separator and wet-concentration mill[2] were idle.

Considerable lead-silver sulphide and 1 car of lead-zinc sulphide ore were shipped from the property of the Summit Mining & Smelting Co.; likewise several cars of lead-silver ore from the Tennessee and other properties of the King Solomon Co., at Frisco; gold ore from the Hyman Tunnel; lead ore from the Boston and from the Mayflower mines; gold-silver ore from the Michigan, Bird's Nest, and F. W. E. mines; and silver ore from the Queen of the West mine.

Montezuma district.[3]—The district in 1915 from 5 mines produced 2,973 tons of ore, yielding $388 in gold, 6,874 ounces of silver, 2,091 pounds of copper, 150,085 pounds of lead, and 298,750 pounds of zinc, with a total value of $48,338, as compared with $32,405 in 1914.

The Bolivar mine and mill were operated for some time, and zinc concentrate was shipped to smelters, as well as several cars of zinc-lead smelting ore. The Montezuma Mines & Milling Co., operating the Silver Wave, Silver Princess, and Chautauqua mines, operated the first two mines for 10 months and constructed a 50-ton concentration and flotation mill, which was started August 1, 1915. The lead is removed by table concentration, which is followed by fine grinding before treatment by froth flotation, the product from the flotation cells being a zinc concentrate. Lessees on the Waterloo mine of the Philadelphia Co. shipped small lots of lead-silver ore direct to smelters, and considerable lead-zinc ore was treated at the company's concentration mill, to which flotation cells were added toward the end of the year. Several shipments of silver-lead ore were made from the St. John Mines Co. property. A small shipment of silver-lead ore was made from the Shoe Basin mine.

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[1] For discussion of geology see Emmons, S. F., U. S. Geol. Survey Geol. Atlas, Tenmile district folio (No. 48), 1898.

[2] For description of mill see Parmelee, H. C., Zinc ore dressing in Colorado: Met. and Chem. Eng., February, 1911, pp. 91–96.

[3] For discussion of geology see Patton, H. R., The Montezuma mining district of Summit County, Colo.: Colorado Geol. Survey First Rept., for 1908, pp. 104–144, 1909.

TELLER COUNTY.

CRIPPLE CREEK DISTRICT.[1]

Mine production of Cripple Creek district, Colo., in 1914 and 1915.

Year.	Number of producing mines.	Ore.	Gold.	Silver.		Total value.
				Quantity.	Value.	
		Short tons.		*Fine ounces.*		
1914	80	939,423	$11,996,116	89,056	$49,248	$12,045,364
1915	70	948,082	13,683,494	87,767	44,498	13,727,992
Increase or decrease, 1915	−10	+8,659	+1,687,378	−1,289	−4,750	+1,682,628

In 1915 there were recovered in the Cripple Creek district by mills and smelters from crude ore and dump ore, from slags, slimes, and "clean-ups" of mills, from stolen bullion and ore, 661,939.02 fine ounces of gold, valued at $13,683,494.

CRIPPLE CREEK DRAINAGE OR ROOSEVELT TUNNEL.

The work on the original tunnel was stopped in March, 1912; drilling on the extension was begun on August 3, 1914, and was continued 270 feet beyond the breast of the original tunnel by September 4, 1914, when the El Paso plant was completely destroyed by fire and the work in the tunnel was stopped. On March 2, 1915, when the new El Paso plant was ready for hoisting, work on the tunnel was resumed. At this time the tunnel was 17,127 feet long, practically 3¼ miles. The course of the original tunnel is N. 44° 20′ E. from the portal to the El Paso shaft, then the extension runs N. 74° 23′ E. On December 31, 1915, the heading was 290 feet from the Elkton shaft and 8,290 feet from the Golden Cycle shaft. In 10 months of 1915 the tunnel was driven 1,920 feet. The total recession of water was 149 feet. The total water discharged was 5,550,000,000 gallons, equal to 37,000,000 gallons per vertical foot. At the close of the year the Elkton shaft was 1,460 feet deep and in February, 1916, the recession of the water at the Elkton shaft had enabled that company to sink the main shaft 125 feet below the sixteenth level, and the tunnel had reached a heading under the Elkton about 150 feet below the bottom of the shaft. During 1915 the Portland No. 2 shaft was sunk 154 feet and the eighteenth level (1,870 feet from the surface) was begun. The drainage brought about by the extension of the tunnel will make it possible to sink No. 2 shaft and open up the nineteenth level during 1916. In April, 1915, the two large electric pumps from the Golden Cycle sixteenth level, together with an additional unit of the same size, were removed and installed on the eighteenth level, where these pumps will remain, and so long as is necessary will pump water from the eighteenth level to the La Bella tunnel level, 300 feet below the surface. Three new centrifugal pumps were ordered at the end of the year and will pump the water from the twentieth level into the

[1] For discussion of geology see Lindgren, Waldemar, and Ransome, F. L., Geology and ore deposits of the Cripple Creek district, Colo.: U. S. Geol. Survey Prof. Paper 54, 1906.

sump on the eighteenth level. The extension of the drainage tunnel will cut the Golden Cycle shaft 65 feet below the eighteenth level. As soon as the tunnel is completed it will only be necessary to pump water from the bottom level to drainage-tunnel level, thus saving a lift of 1,665 feet. The drainage tunnel at the end of 1915 was being driven ahead at the rate of about 300 feet a month (although better progress than this has been accomplished in 1916). As soon as shaft-sinking operations at the Golden Cycle are finished and the centrifugal pumps are installed on the twentieth level, it is planned to commence a drive of the tunnel from the Golden Cycle shaft to connect eventually with the main heading. The cost of pumping at the Golden Cycle for 1915 was $41,273.

MILLS AT COLORADO CITY.

As usual, 96 per cent of the original crude ore from the Cripple Creek district was treated at mills in the district or at custom mills near Colorado City, with a product chiefly of refined gold bars from cyanide precipitates. The remainder of the crude ore (the higher grade), part of the concentrates produced, the unrefined cyanide precipitates, slags, and the "clean-up" material went to smelters and smelter refineries. The contents of ore, concentrates, slags, and "clean-up" material sent to smelters represented 17.5 per cent of the total output of gold and 47 per cent of the total yield of silver in the district.

The active valley mills adjoining Colorado City were the Golden Cycle, a roast-cyanide (with subsidiary amalgamation) plant[1] of 1,200 tons daily capacity, and the Portland, a 400-ton roast-cyanide concentration mill. The Standard mill, a chlorination and concentration plant with cyanide annex, was idle.

At Florence, Fremont County, the tailings of the Old Union chlorination plant were treated from 1911 to 1913 in a 500-ton cyanide plant, built in 1911 by the United States Reduction & Refining Co. This plant was idle in 1914 and 1915.

MILLS IN THE CRIPPLE CREEK DISTRICT.

The Stratton's Independence mill,[2] at Victor, began operation in April, 1909, with a capacity of 4,500 tons a month, was enlarged to treat 7,000 tons in December of that year, and in November, 1910, with the addition of the second unit, attained a capacity of 9,000 tons. During 1911 the capacity was brought up to approximately 10,000 tons a month. The report[3] for the year ended June 30, 1915, chronicles the end of the Stratton's Independence Co., as the mine and mill was sold to the Portland Gold Mining Co. for $325,000 on June 30. Details of the mill operation since 1909 are as follows:

In 1907 Philip Argall, the consulting engineer, made a report to the company estimating that its dump ores could be treated at an operating cost of $1.52 per ton, treating 10,000 tons a day, and 70 per cent recovery, based upon tests indicating 74.22 per cent recovery. In making this estimate Mr. Argall figures $3.60 per ton as average grade based upon previous sampling indicating about $3.80

[1] For description see Milliken, J. T., Colorado Bur. Mines Thirteenth Bien. Rept., for 1913–14, pp. 72–74, 1914.

[2] For description see Argall, Philip, idem, pp. 80–86.

[3] Eng. and Min. Jour., Mar. 11, 1916, p. 482; also Met. and Chem. Eng., Mar. 1, 1916. p. 242.

per ton. The actual average milled was by assay 0.1522 ounce gold per ton. The following table is a six years' summary of milling operations on these dump ores:

Year.	Ore.	Gold assay per ton.	Gold.			
			Total.	Extracted.	Cost.	Per ton.
	Tons.		*Ounces.*	*Per cent.*		
1909–10	68,711	0.16150	11,097.750	67.87	$122,914.12	$1.7880
1910–11	109,800	.15700	17,288.960	71.50	180,340.25	1.7330
1911–12	112,391	.15500	17,428.215	73.63	167,710.65	1.5000
1912–13	130,110	.15380	20,012.929	78.48	184,186.52	1.4400
1913–14	133,875	.14396	19,273.469	80.00	184,898.31	1.3800
1914–15	116,778	.14680	17,146.607	75.97	176,717.28	1.5130
	671,665	.15220	102,247.930	74.57	1,016,767.13	1.5138

The Portland Gold Mining Co.'s new concentration cyanide (non-roast) mill was completed at Victor in June, 1910. The annual report of the Portland Co. for the calendar year 1915, says, regarding the Victor and Stratton's Independence mills:

The Victor mill * * * treated 213,122 tons of a gross value of $3.033 per ton. Of this tonnage, 44,948 tons was reject from No. 1 ore house, 78,663 tons reject from No. 2 ore house, 21,847 tons from development work, 42,305 tons from stopes direct, and the balance of ore treated was taken by the mill direct from the No. 2 dump, and as part of it was screened out before treatment, there is no accurate record of the amount.

Possession was taken of the Independence mill July 1, 1915, and since that time more attention has been paid to the proposed changes and enlargements than to the treatment of ores, although a moderate tonnage was treated.

The experiments of our metallurgical engineers have proved that the new oil flotation process now being extensively used in the United States and in foreign countries in the treatment of copper, lead, and zinc-silver ores, is equally as efficient in the treatment of the gold ores of the Cripple Creek district. After an exhaustive investigation of the process, following this discovery, the board of directors decided to change the Stratton's Independence mill into a flotation plant, and to enlarge it to 1,000 tons daily capacity. Work on such remodeling and enlargement was commenced immediately after this decision, and more than one-quarter of the plant is now in successful operation under the new process. For the present, the Colorado Springs mill will continue to treat the higher grade ores by the cyanide process, but later in the year the Victor mill will be changed into a flotation plant and also enlarged to a capacity of 1,000 tons daily. It will be seen by the foregoing that upon the completion of the improvements and enlargements under way at the Independence mill, and the contemplated changes in your Victor plant, the total milling capacity of your low-grade plants will be 2,000 tons daily, which is sufficient to handle the ores now available.

To December 31, 1915, the Portland and Independence mines owned by your company, comprising over 250 acres of highly mineralized land in the most productive portion of the Cripple Creek district, had produced 3,653,969 tons of ore having a gross value of $64,426,370. It is estimated that, in and adjacent to the workings from which this immense tonnage of high-grade ore came, and on the dumps of these mines, there still remains from 10,000,000 to 15,000,000 tons of low-grade ore that can be treated at a profit, by either the cyanide or the oil-flotation process, if handled in large quantities as your directors propose. Leaving out of consideration the very large tonnage of custom ores that will be secured, a 2,000-ton plant could be run to capacity on the low-grade ores of your mines for many years. Experience has demonstrated that large deposits of low-grade ores, economically handled, give stability to mining companies, and this is demonstrated in our case by the fact that the low-grade ores of the Portland mines and dumps, which were valueless a few years ago, will insure the dividends of the future.

Other operating mills in the district were the Colburn-Ajax, a 300-ton concentration and cyanide mill,[1] operated 333 days; the Dante (Gaylord) 75-ton cyanide leaching plant, operated intermittently until destroyed by fire November 1, 1915; the Isabella 50-ton coarse-crushing cyanide leaching mill, operated for a period; the Jo Dandy (Kavanaugh), operated on dump ore from July 15 to September 25; the new Jerry Johnson (Caley) 100-ton cyanide mill, operated from September to the end of 1915; and the Wild Horse 50-ton coarse-crushing cyanide leaching plant, operated part of the year. The Free Coinage 60-ton cyanide and concentration plant (new in 1914); the Blue Flag 125-ton continuous agitation cyanide mill; and the Rex (Iron Clad) 100-ton cyanide leaching plant were idle.

MINES REVIEW.

Poverty Gulch.—The Abe Lincoln, C. O. D., and Gold King mines were producers.

Tenderfoot Hill.—Shipping ore was opened on the surface in several properties in this district in July, and several cars of ore were shipped from the Ella W. and Black Diamond mines. Considerable development work was done on the Ella W. and some work was done on the Mollie Kathleen and Queen Bess properties.

Globe Hill.—A considerable production was made from the Stratton Estate mines on this hill.

Hoosier Pass.—No production was made from the Hoosier mine.

North slope of Ironclad Hill.—Producing mines were the Jerry Johnson, W. P. H., and Damon. The twelfth annual report of the Jerry Johnson Gold Mining Co., dated September 13, 1915, for the year ending August 31, 1915, says:

* * * the shipment of ore * * * has been very limited, as the mine has been shut down since February 1, 1915, and * * * the lessee has been * * * putting up a cyanide mill of 100 tons capacity * * *. Sail mill has just been completed and the crushing of low-grade ore began on September 4, 1915. On April 15, 1915, a lease from the 650-foot level down was made to the Cripple Creek Deep Leasing Co. * * * The development work of this company has opened up a body of low-grade ore on the 850-foot level * * *. There was shipped during the past fiscal year 1,255 dry tons, gross value $22,546; freight, hauling, and treatment, $7,682; net value, $14,864.

During the remainder of the year the mill shipped several lots of bullion and several cars of concentrates. The W. P. H. and Damon mines were operated by the United Gold Mines Co., whose properties comprise a large acreage on Bull Hill as well as on Ironclad Hill.

Gold Hill.—Producing mines were the Anchoria-Leland, Caledonia, Clara D., Matoa, Midget, and Moon-Anchor.

Raven and Guyot Hills.—Producing mines were the Cresson, Doctor-Jack Pot, Elkton, Jennie Sample, Jo Dandy, Katinka, Mary McKinney, and Peggy.

To the Cresson property (to which in 1914 had been added much additional territory, including the Trilby and Maggie mines), must be credited much of the increased yield of the district in 1915. The extremely high-grade ore discovery of December, 1914, resulted in shipments to the Golden Cycle mill during January and February, 1915, which caused the March output of bullion from that mill to

[1] For description see Bryan, R. R., idem, pp. 75–76.

surpass all previous records. (Other large increases were shown by the Portland and Vindicator-Golden Cycle properties.)

The Doctor-Jack Pot Co., to which in 1915 had also been added by legal decision the Rose Maud mine and various properties of the former Work Co., produced 14,382 tons, averaging $19.98 per ton.

The twenty-third annual report of the Elkton Co. for the calendar year 1915, dated February 14, 1916, says:

After many years of continuous dividend payments and the disbursing of dividends for the first and second quarters of 1915, amounting to upwards of three and one-half millions of dollars, your board of directors deemed it wise and necessary to discontinue the same for the reason that the known ore reserves above the sixteenth level were largely depleted, and the remaining treasury balance and profit from ore shipments were needed for further developments until such time as greater depth could be gained with the main shaft.

At the date of this report the water recession has enabled the management to sink the main shaft 125 feet below the sixteenth level, at which point a station is now being cut and equipped, and within the next few days the vein should be opened up for the usual drifting. This will give a stoping area of 125 feet on the whole length of the ore shoot, and therefore we anticipate normal shipments of ore in the near future.

The Roosevelt drainage tunnel has now reached a heading underneath the Elkton shaft about 150 feet below the bottom of the shaft. As rapidly as possible the shaft will be sunk to a connection, which will open up another stoping area of no less than 150 feet. * * * The development work of most importance was the securing of greater depth to the Elkton main shaft as rapidly as water receded. The recession was at the rate of 12½ feet per month. The Elkton shaft, at the close of the year, was 1,460 feet in depth. * * *

Company ore production was 16,528 dry tons, averaging $18.42 per ton. Average value per ton for 1914 was $18.37, for 1913 $18.88, and for 1912, $19.01. In addition to company production, 43 sets of lessees operated on the properties, producing 20,420 dry tons of ore carrying an average gold content of $9.53 per ton. Thirteen sets of these lessees operated at a profit to themselves, the remaining thirty at a loss. * * *

The Roosevelt drainage tunnel entered the company's territory on November 25. The distance to be traversed through the Elkton properties on an easterly course will be 1,140 feet, at an average depth of 275 feet below the sixteenth level. This tunnel should cut the Elkton, Walter, and Henley vein systems at practically right angles. * * *

The Arequa lease, which the company holds on Raven & Beacon Hill Mining Co.'s territory, shows a slight loss for the year. * * *

The report of the Mary McKinney Co. for the calendar year 1915 shows that there were produced on company account 6,263 tons of ore, with a gross value of $161,445, and by lessees, 5,145 tons, with a gross value of $97,084. During the year the shaft was sunk to the eleventh level. The company is now sinking the shaft and will cut a station for the twelfth level, 125 feet below the eleventh, about March 1, 1916. A large quantity of low-grade ore was shipped from the old Economic mill dump.

Beacon Hill.—Producing mines were the Banner, Raaler (C. K. and N.), El Paso, Gold Dollar, Mabel M., Old Gold, and Prince Albert.

The annual report[1] of the El Paso Gold Mining Co. for the fiscal year (dated Apr. 1, 1916) says:

* * * But very little ore was in sight and most of it low grade. During the years 1913 and 1914 the company had made no profits and had exhausted its treasury surplus, was about $70,000 in debt, and doing business largely upon credit. The leasing system to a general depth of 700 feet heretofore existing was carried

[1] See Min. and Eng. World, Apr. 22, 1916, p. 800; also Min. and Sci. Press, Apr. 29, 1916, p. 654.

on and there are now 16 leases in operation. * * * The company produced and sold 28,448 tons, the lessees produced and sold 9,994 tons, making a total of 38,442 tons. From these ore sales the company realized, including royalties from lessees, $129,546. The superintendent has kept from three to six drills on dead work searching for ore, and has performed 4,230 feet of crosscutting, drifting, raising, and winzing. Profits to the company on the ore mined and sold by it, together with the royalties from lessees, have been * * * a total of $37,433 from April, 1915, to March 1, 1916. * * * We have broken in the stopes about 7,000 tons of ore ready for shipment, and have in sight for breaking probably about 12,000 tons. The lower levels of the mine, including the tunnel level on the C. K. & N. vein, which has been the heaviest and best producer, appears to be low grade so far as exposed. However, there are possibilities of high-grade ore being opened in the upper levels of the mine yet to be discovered by exploration. We have been offered a royalty lease for the working of our low-grade and dump ores by the flotation on a 15-cent royalty basis. * * *

Bull Hill.—Producing mines were the Block 8, School Section 16, Blue Bird, Dante, Dexter, Gold Sovereign, Last Dollar, Modoc, Ramona, Sheriff, Stratton Estate mines (American Eagles, Orpha May, War Eagle, Zenobia, etc.), Trail, and Wild Horse.

The United Gold Mines Co., controlling the Trail, Trachyte, and Wild Horse mines and mill on Bull Hill and the Damon and W. P. H. mines on Ironclad Hill, reported production by lessees of 13,966 tons of a gross value of $181,657.

Mines between Altman and Goldfield.—The producing mines were the Burns, Christmas, Findley, Golden Cycle, Isabella, Mountain Beauty, Pharmacist, Shurtloff, Victory, and Vindicator.

The annual report of the Isabella Mines Co. for the calendar year 1915 (dated Feb. 2, 1916) says:

* * * The production for the year amounted to 24,698 tons, with a gross value of $507,792. The average grade of this ore was a little in excess of $20 per ton, which is considerably above the average of the camp's production. The above production is an increase of 47 per cent over that of 1914, and 108 per cent over the production of 1913.

Year.	Tons mine ore.	Tons dump ore.	Total tonnage.	Gross value.
1913	11,385	6,903	18,288	$243,252
1914	15,706	2,040	17,746	345,820
1915	23,861	837	24,698	507,792

More ore is in sight and broken than at the beginning of the year, and development work now being prosecuted has greater possibilities for the future of your mine than any work done in the last few years. A great deal of development work is being done on the lower levels of the mine, for a long time considered barren, and considerable ore is being mined from these levels. Only within the last few days the company work on the bottom, or 1,275-foot level, has opened and is developing ore of high value. * * *

The Isabella mill has recently been put into working order at a heavy expense by lessees and is now operating at nearly full capacity on low-grade dump ore. A tunnel is being driven on the elevation of the mill bins, under the ore house dumps, into which these dumps will be drawn and taken to the mill. This tunnel is to be continued to the Buena Vista stope, into which all ore of a milling grade from the mine will be dropped from the surface.

The Vindicator Consolidated Gold Mining Co. in its annual report for 1915 (dated Jan. 25, 1916) says:

There has been mined during 12 months operation of the Vindicator mine and 10 months operation of the Golden Cycle mine, 218,487 tons of crude ore, which have produced 125,397 tons of shipping ore, of an average gold content of $23.73 per ton.

The gross value of company shipments was $2,164,669; after deducting freight and treatment, the net receipts from the sale of ore amounted to $1,718,022. Lessees over the same period shipped 49,188 tons of ore of an average gold content of $16.57 per ton, the gross value of which was $815,182; and, after deducting freight and treatment charges, the net receipts were $546,363.

The company received $251,624 net royalties from lease operations.

Development of ore reserves has more than kept pace with production, and the indications are that the year 1916 will be a prosperous one.

In October, 1914, the new Vindicator concentrating mill, which was designed to handle the reject from the ore house and produce a shipping product from material that would otherwise have been waste, was put in operation, but it was not until the first part of 1915 that the mill received full tonnage. Actual operations, over a period of 15 months, have shown that it has admirably fulfilled its purpose; in fact, in nearly every department better results have been obtained than indicated from the experimental work. During the year the mill has handled an average daily tonnage of 250 tons in one shift of eight hours. An average ratio of concentration of 11 to 1 has been maintained. The percentage of recovery in the handling of ores of an average value of $2 has averaged about 55 per cent. The profits for milling operations have maintained an average of nearly double what was indicated from the experimental plant, largely due to the fact that our milling costs are only 20 cents per ton. A complete return of the capital expended was shown after only 12 months operation.

The routine development and stoping operations have been maintained, and the results have been uniformly satisfactory. Stoping operations in the large ore bodies found on the 1,600-foot south system of veins have been vigorously prosecuted. Operations on the No. 1 South vein, which was found on the sixteenth level, and had not been developed on the fifteenth level, have proved that this ore body extends not only up to the fifteenth level but beyond; and at about 40 feet above this level appears to be forming an intersection with the Middle vein, making a very large ore body. As this junction has been opened only within the last few weeks, its extent has not yet been determined. On account of the width of the No. 3 South vein, square sets have been used for timbering, and in the course of stoping operations the vein has maintained its width and values. During the past year the most important new development on the main Vindicator shaft was the discovery and opening up of the new "Middle" vein. This is an ore shoot running diagonally across the general direction of the fissuring and vein systems.

The Middle vein was first opened on the 1,000-foot level in the course of stoping operations in the No. 1 North Spur stope. The ore body started in rather a small way, but increased steadily as progress was made. Eventually a continuous ore body was developed connecting the No. 1 North vein with the No. 1 South vein. The Middle vein, as developed on the 1,600-foot level, is 400 feet long, with an average width of 35 feet. The importance of the discovery of the Middle vein, aside from the large amount of ore already exposed, lies in the fact of its being found in territory heretofore regarded as barren. * * *

As soon as it was realized that the Middl evein was not a spur but a new ore body, development work was at once started on the 1,500-foot level. A crosscut of but 60 feet opened up the vein on this level, but at the present time the ore body is not fully developed. However, we have exposed an ore shoot 225 feet long, with ore in the breast and both walls in ore of very good value. The Middle vein has been opened on the fourteenth level and the eighteenth level, only within the past month, but development work on both levels is showing some very satisfactory values.

In the Golden Cycle mine, the principal ore body, the Ready Money vein, was cut in April on the new eighteenth level, 1,900 feet below the collar of the shaft. The ore body as here developed has shown a much greater length than that exposed on the seventeenth level but is not so wide and is of lesser value. A crosscut is being driven at the present time on the nineteenth level to cut the Ready Money vein and should intersect it within the next 30 days. On the eighteenth level, at the junction of the Revenue and Carr veins, an ore body has been cut within the last 60 days of considerably greater magnitude, both as to size of the vein and value of the ore, than was found on the seventeenth level. The ore shoot, as now developed, is 50 feet long, with ore in both breasts. During the year the Golden Cycle shaft has been sunk from the eighteenth level to the twentieth level, or a total depth of 2,210 feet below the collar. A station was cut on the nineteenth level at 2,024 feet, and a station and pump room was cut on the twentieth level at a depth of 2,150 feet.

Since we took over the Golden Cycle mine, we have done a large amount of prospecting work, with a view of thoroughly exploring the property. Since the 1st of March our development work on the Golden Cycle shows a total of 3,171 feet of crosscuts and 4,820 feet of drifts, as compared to 2,071 feet of crosscuts and 4,486 feet of drifts on the Vindicator for 12 months. In the course of the year considerable development work was accomplished by lessees. On the Golden Cycle property lessees drove a total of 2,702 feet of crosscuts and 3,807 feet of drifts, as compared to the lessees' development on the Vindicator of 270 feet of crosscuts and 1,944 feet of drifts for the year.

In April the two large electric pumps were moved from the Golden Cycle sixteenth level and, together with an additional unit of the same size, were installed on the eighteenth level, where these pumps will remain and, so long as is necessary, will pump the water from the eighteenth level to the La Bella Tunnel level, 300 feet below the surface. Three new centrifugal pumps have been ordered and will be installed on the twentieth level. These pumps will pump the water from the twentieth level into the sump on the eighteenth level. The extension of the Cripple Creek drainage tunnel will cut the Golden Cycle shaft 65 feet below the eighteenth level, and as soon as the tunnel is completed it will only be necessary to pump water from our bottom level to the drainage tunnel level, thus saving a lift of 1,665 feet. The Cripple Creek drainage tunnel is being driven ahead at the rate of about 300 feet per month. On January 1 the heading was 290 feet from the Elkton shaft and 8,290 feet from the Golden Cycle shaft. As soon as our shaft-sinking operations are finished and the centrifugal pumps are installed on the Golden Cycle twentieth level, it is planned to commence a drive of the tunnel from the Golden Cycle shaft to eventually connect with the main heading, which is being driven in our direction from the Elkton shaft. The cost of pumping to our company for the past year was $41,272.91, so that it is essential that the tunnel reach the Vindicator property as soon as possible. * * *

There is a large amount of low-grade ore on the dumps of the property, averaging $2 a ton or better and estimated in quantity at not less than 2,000,000 tons, besides large blocks of low-grade ore in the mine and filled stopes which can not be worked at a profit with present metallurgical practice. * * * A simple screening and washing plant on the plan of the present Vindicator concentrator can not be expected to accomplish this, so in order to exploit this field thoroughly two metallurgical engineers have been employed since July. In this time these engineers have tried various methods of flotation and cyanide extraction, both in laboratory tests and in actual working quantities, and are now using a flotation unit of a capacity of 10 tons a day. The results of these experiments have led the engineers to recommend the remodeling of the concentrator at the Golden Cycle shaft, which is now obsolete, into a flotation unit of 300 tons daily capacity, sufficient to treat all the rejected material from the Golden Cycle ore house, as well as to experiment on all grades of ores from both shafts. The cost of this change will not be great, as the building and part of the machinery can be utilized; and we can look for an extraction of 90 per cent of the values at a cost of less than $1 per ton. This plant will enable us to determine the best and most economical process to use on the ores we have. * * *

Battle Mountain.—Producing mines were the Ajax, Carbonate Queen, Coriolanus, Dead Pine, Granite, Gold Coin, Mary Cashen, Portland, Stratton's Independence, and Strong.

The report[1] for the Stratton's Independence mine for the fiscal year ended June 30, 1915, reports the sale of the mine to the Portland Gold Mining Co. and reviews the operations as follows:

Total gross production of Stratton's Independence mine, 1891 to June 30, 1915.

By late W. S. Stratton	$3,985,400
By first English company operating on company account, 1898–1904	11,049,030
By the same company operating by lessees, 1904–1908	4,015,290
By the present company, 1908–1915	4,571,968
	23,621,728

[1] Eng. and Min. Jour., Mar. 11, 1916, p. 482; also Met. and Chem. Eng., Mar. 1, 1916, p. 242.

The ore produced and the earnings of the mine, as stated in the report, follow:

Ore produced and sold.

	Tons.
By Mr. Stratton	41,694
By first English company	323,270
By first English company, lessee	104,040
By the present company	104,729
Total shipping ore	573,733
Ore milled by the present company, 1908–1915	685,130
Total production to June 30, 1915	1,258,863

The earnings of the mine.

Profit by Mr. Stratton	$2,402,164
Dividends by first English company, 1898–1904	4,142,739
Dividends by the same company leasing, 1904–1908	606,250
Dividends by the present company	455,625
Cash as at Sept. 30, 1915 (approximately)	510,000
	8,116,778

The twenty-second annual report of the Portland Gold Mining Co., for the year ending December 31, 1915 (dated February 27, 1916), says:

The gross production amounted to 280,528 tons of a gross value of $2,287,498.56. Of this amount, 55,339 tons were shipped to your Colorado Springs plant and had a gross value of $24.685 per ton, an increase of $1.264 over the preceding year. Lessees shipped 12,067 tons of a gross value of $22,75 per ton. In addition, the Victor mill of your company treated 213,122 tons of a gross value of $3.033 per ton. There has been a substantial increase in the value of all ore milled over the preceding period.

The mine worked two shifts steadily. There was no change in the mining methods, all waste being used for back filling. Filled stopes have been the practice whenever possible. Leasing operations have been extended and now embrace the territory above the adit tunnel level, in addition to the 200-foot level of the No. 1 shaft. Net returns to your company from leasing operations show a royalty of 29 per cent after all charges are made against development, hoisting, general expense, etc. In addition the company receives, at no cost, all mill ore from development and reject from the ore houses, which is of considerable value. When it is remembered that this revenue comes from territory that has been worked by the company until no longer profitable, the merits of the leasing system must be admitted.

The total development amounted to 19,808 feet, an excess of 4,216 feet over the preceding year. The new ore developed amounted to 3.6 tons for each foot of development, and 35 new stopes were opened.

The new ore opened by development has shown a substantial decrease over the preceding period, notably on the upper levels. This is accounted for partly by the fact that the present ore zones are more thoroughly prospected and that no important finds were made in new territory. The main vein system has held its size and values fully as well as was expected. In fact, there has been an unusual concentration of values where least expected in the deepest workings. The No. 2 shaft was sunk during the summer and the main No. 1 vein opened. Drifting was started September 15, and 1,480 feet of the vein has been exposed to date. Six hundred feet is in ore of shipping grade, 200 feet is in possible ore, 350 feet will stope a good grade of mill dirt, and 330 feet is barren, from which I do not expect any ore of consequence. There has been a marked change on this level, quite different from the conditions existing on the 1,700-foot level, 150 feet above. The ground is more broken, there is evidence of fissuring and the shifting of the contact, new to this vein. To the north the vein is larger and has held its size and direction farther than on 1,700 but with less values. To the south the change is more pronounced, the vein having split or divided

at a point 325 feet south of the main crosscut, the west branch following the granite contact, the east branch following the phonolite dyke in the breccia area. Both veins were in pay ore after leaving the junction a short distance. Shipping ore for a distance of 100 feet has been developed in the west branch, the values fading out at the breast. The east vein is being driven ahead two shifts per day, and is making ore of a grade of $25 per ton when broken 5 feet wide. Stoping ground on this vein will amount to 150 feet, with a shipping value of $40 per ton.

On account of the conditions referred to, I do not believe the possibilities of this level have been more than partly developed. Crosscutting will likely show where the values have shifted.

You can reasonably expect the 1,800-foot level to show fully as much net profit as the level above.

The 1,700-foot level was actively developed during the year under review, a total of 6,134 feet of work having been done during the year. In connection with the 5,816 feet of crosscutting done on this level, nothing has been found aside from the main vein systems. The country rock does not show marked alteration from that nearer the surface, except an absence of fissuring and scarcity of veins.

It is planned to sink the No. 2 shaft another hundred feet, commencing February 1. This, with the 1,800-foot level only partially developed, will add to the ore in sight and maintain the present production and grade of shipping ore to the Colorado Springs plant.

* * * * * * *

We are now sinking a winze on the Bobtail vein in the granite area that is making $30 ore when broken 5 feet wide. If these values continue, the No. 1 shaft will be sunk some time this coming summer and the known veins tributary to this point will be developed. Taken as a whole, the outlook for 1916 is encouraging, and good profits can confidently be expected from the shipment of high-grade ores.

The drainage brought about by a further extension of the Roosevelt tunnel, which is now under way, will make it possible to further sink No. 2 shaft and open up the nineteenth level during the coming year, work on which will be commenced in the near future.

Although the Portland mine has been worked continuously for 23 years, and has over 55 miles of underground workings, every level still contributed to the output of the year. Only one level, and that the 200-foot level, has been given over to lessees. The tonnage of high-grade ore shipped from your mines each year is limited by the financial needs of your company, and not by the capacity of the mines. * * * The Stratton's Independence mining properties, adjoining the Portland mine, consisting of 110 acres of mineral land, were purchased in June, 1915, at a cost of $325,000. The acquisition of this tract necessarily will have a most important and favorable influence upon the future of your company. There is a cyanide mill on the property, having a capacity for treating 350 tons daily. The original cost of the buildings and equipment of this mill alone was considerably more than the purchase price paid for the entire property. The mill is admirably located at the foot of Battle Mountain, on which the Portland properties are located, and there is ample room around the plant for future enlargement. It has an abundance of railway trackage, and upon the completion of the sampling works now under construction there will be every needed facility for an economical handling of custom ores, which is to be an important part of the Portland Co.'s business in the future. The immense tonnage of low-grade ore in the Portland and adjacent mines can now be brought to the Independence mill by gravity haulage, and last but not least in importance is the ample dump room for tailings, acquired through the Independence purchase.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN ARIZONA.

(MINES REPORT.)

By V. C. Heikes.

PRODUCTION.

The mines of Arizona produced, in 1915, gold, silver, copper, lead, and zinc valued at $90,806,349, contained in bullion, ore of shipping grade, and concentrates. The value of the output when compared with that of 1914 increased $30,850,320. There were 468 producers from deep mines and 49 producers from placers, as against 338 deep mine and 57 placer producers in 1914. The increase in the value of the metal output in 1915 was principally in copper, but there was also an increase in silver, lead, and zinc, and a small decrease in gold.

Number of producers, ore sold or treated in Arizona in 1914 and 1915, and content in gold, silver, copper, lead, and zinc.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	395	8,009,927	$4,179,155	4,377,994	393,017,400	15,003,068	9,792,337	$59,956,029
1915	517	9,612,559	4,166,025	5,649,020	459,972,295	21,738,969	18,220,863	90,806,349
Increase or decrease, 1915.		+1,602,632	−13,130	+1,271,026	+66,954,895	+6,735,901	+8,428,526	+30,850,320

[a] Includes placer production.

ORE.

Arizona is credited with a total production of 9,612,559 tons of ore in 1915, which, notwithstanding the curtailment of operation in the first part of the year, was 1,602,632 tons more than the output in 1914. The total average value per ton increased from $7.49 in 1914 to $9.44 in 1915, but the gold and silver value decreased from 82 cents to 73 cents a ton. The dry or siliceous ores decreased from 428,805 tons in 1914, to 340,798 tons in 1915. This classification includes 182,251 tons of siliceous gold ore, averaging $10.52 in gold

and 0.39 ounce of silver a ton. These ores were principally from Mohave, Maricopa, Yavapai, and Pinal counties. Gold and silver ores, dry or siliceous in character, produced in various districts, aggregated 14,349 tons and averaged $3.44 in gold, 5.75 ounces of silver, and 27.59 pounds of copper. The siliceous silver ores produced in 1915 aggregated 144,198 tons, averaging per ton $1.32 in gold, 5.82 ounces of silver, 0.24 pound of copper, and 0.35 pound of lead. These ores were produced chiefly in the Turquoise and Tombstone districts of Cochise County.

The copper ore, mined by 246 producers, amounted to 9,134,425 tons, against 7,508,020 tons mined by 125 producers in 1914. The copper ore mined in 1915 included the low-grade schist and "porphyry" copper ores at Ray and in the Globe district, where 5,060,492 tons were treated at concentration mills. Similar ores amounting to 1,093,165 tons were mined and milled for copper in Greenlee County, which embraces the Clifton and Morenci camps. Thus, the total output of schist and "porphyry" ores amounted to 6,153,657 tons, yielding 164,483,500 pounds of copper, or about 36 per cent of the total output of copper. There were mined and smelted directly (without previous concentration) 2,558,301 tons of crude copper ores, averaging 65 cents in gold and 1.32 ounces of silver, and 5.21 per cent of copper, with a total value of $19.55 a ton, against 2,135,614 tons in 1914, with an average value of $15.44 a ton. Of the copper ores smelted directly, 2,124,977 tons were sulphides averaging 75 cents in gold, 1.47 ounces of silver, and 5.15 per cent of copper, and having an average value of $19.52 a ton. The oxidized copper ore smelted, 433,324 tons in quantity, contained 13 cents in gold, 0.55 ounce of silver, and 5.51 per cent of copper, and was valued at $19.71 a ton. There was an increase in the quantity of lead ores smelted, which amounted to 34,938 tons in 1915, against 26,015 tons in 1914. The larger part, or 32,511 tons, was oxidized and 2,427 tons were sulphide ores. The former contained $1.48 in gold, 9.28 ouces of silver, 1.43 per cent of copper, and 18 per cent of lead, and had a total average value of $28.11 a ton. The quantity of zinc ores mined increased from 18,079 tons in 1914, to 40,458 tons in 1915. Of this ore, 2,258 tons mainly sulphide ores were shipped crude to smelters. The remainder of the zinc ore, 35,700 tons, and 2,500 tons of old tailing were concentrated and yielded 12,583 tons of concentrate. The lead-zinc ores amounted to 47,916 tons, of which 33 tons of sulphides were shipped to the smelters and 33,245 tons of ore and 14,638 tons of old tailing were concentrated, yielding 12.893 tons of zinc concentrate and 9,345 tons of lead concentrate. The copper-lead ore, 426 tons in quantity, was mostly oxidized, there being only 72 tons classified as sulphides. The oxidized ores contained $5.53 in gold, 20.71 ounces of silver, 5.17 per cent of copper, and 14.92 per cent of lead, and had an average value of $48.15 a ton.

Ore and metals produced in Arizona in 1915.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter.)
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	49	.....	1,705.12	309	.....	.....	.....
Dry or siliceous ore	170	340,798	104,350.00	994,184	488,011	305,724	48,580
Copper ore	246	9,134,425	87,706.63	4,010,510	458,423,611	1,011	.....
Lead ore	56	48,536	2,735.36	393,444	955,665	14,892,854	.....
Zinc ore	8	40,458	2,728.01	64,547	13,297	350,000	9,776,391
Copper-lead ore	15	426	103.38	13,923	45,502	125,230	.....
Lead-zinc ore	3	47,916	2,202.96	172,103	46,209	6,064,150	8,395,892
	.....	9,612,559	201,531.46	5,649,020	459,972,295	21,738,969	18,220,863

Ore sold or treated in Arizona in 1915, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Cochise	157,708	1,692,840	37,742	102	10	33	1,888,435
Coconino	.....	200	.....	.....	.....	.....	200
Gila	532	2,574,839	254	.....	24	.....	2,575,649
Graham	.....	97	226	.....	.....	.....	323
Greenlee	778	1,266,121	.....	.....	.....	.....	1,266,899
Maricopa	31,023	94	6	.....	.....	.....	31,123
Mohave	136,378	5,501	603	37,070	.....	47,883	227,435
Pima	75	34,619	72	460	168	.....	35,394
Pinal	1,205	2,925,654	1,721	26	33	.....	2,928,639
Santa Cruz	385	3,860	7,136	2,800	179	.....	14,360
Yavapai	12,143	602,357	336	.....	7	.....	614,843
Yuma	571	28,243	440	.....	5	.....	29,259
	[a] 340,798	9,134,425	48,536	40,458	426	47,916	9,612,559
Value per ton in gold and silver	$7.81	$0.42	$5.27	$2.20	$21.59	$2.77	$0.73

[a] Includes 182,251 tons of gold ore, 14,349 tons of gold and silver ore, and 144,198 tons of silver ore.

GOLD.

Arizona ores, placer dust, and bullion in 1915 yielded 201,531.46 ounces of gold, valued at $4,166,025. Of this value, $35,248, against $30,140 in 1914, came from placers, $2,157,106, against $3,002,702 in 1914, from dry or siliceous ore, and $1,813,057, against $1,051,014 in 1914, from copper ores. The mines of Mohave County produced the largest output of gold, $1,626,437 in 1915, against $1,891,214 in 1914, $1,874,547 in 1913, and $1,899,131 in 1912. The Tom Reed and Gold Road mines were the largest contributors. Gold recovered from ores treated at gold and silver mills represented 46 per cent of the total production, and crude ores shipped to the smelters about 44 per cent. From ores treated in mills by amalgamation the gold amounted to $142,318 and from ores treated by cyanidation to $1,779,433. Concentrates contained $384,190, as against $318,166 in 1914, and ores shipped directly to smelters contained $1,821,171, against $1,410,606 in 1914. The chief producing districts in 1915 were the San Francisco district in Mohave County, where siliceous ores were produced, and the Warren or Bisbee district in Cochise County, where copper ores were produced.

Mine production of gold in Arizona in 1915, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Cochise	86.01	11,623.80	45,132.01	2,363.14	.....	.....	0.33	59,205.29
Coconino	.....	.....	37.01	.....	.....	.....	.....	37.01
Gila	.....	749.33	3,262.30	108.86	.....	.....	.....	4,120.49
Graham	.....	.....	4.40	.58	.....	.....	.....	4.98
Greenlee	39.14	245.59	2,031.66	.....	.....	.....	.....	2,316.39
Maricopa	48.28	13,397.83	16.66	5.31	.....	.....	.....	13,468.08
Mohave	.....	73,142.01	395.91	210.33	2,728.01	.....	2,202.63	78,678.89
Pima	127.52	75.45	103.41	15.39	.....	8.25	.....	330.02
Pinal	29.31	603.31	2,280.57	.99	.....	1.38	.....	2,915.56
Santa Cruz	24.48	82.34	94.81	24.44	.....	93.30	.....	319.37
Yavapai	672.89	3,575.26	34,053.49	5.45	.....	.30	.....	38,307.39
Yuma	677.49	855.08	294.40	.87	.....	.15	.....	1,827.99
	1,705.12	[a] 104,350.00	87,706.63	2,735.36	2,728.01	103.38	2,202.96	201,531.46

[a] Includes 92,771.19 ounces from gold ore, 2,388.97 ounces from gold and silver ore, and 9,189.84 ounces from silver ore.

SILVER.

The mine output of silver in Arizona increased from 4,377,994 ounces, valued at $2,421,031, in 1914 to 5,649,020 ounces, valued at $2,864,053, in 1915. Of this output, 4,010,510 ounces came from copper ore, 994,184 ounces from dry or siliceous ore, 393,444 ounces from lead ore, 172,103 ounces from lead-zinc ore, and smaller quantities from zinc and copper-lead ores. The greatest increase of silver was in Yavapai, Cochise, Pinal, and Mohave counties, principally from copper ores. Bullion recovered from gold and silver ores, principally by cyanidation (739,781 ounces), yielded 741,578 ounces of silver in 1915. Concentrates contained 910,138 ounces and crude ore shipped to smelters contained 3,945,730 ounces, representing over 69 per cent of the total output. Cochise County mines led in production of silver, producing 3,034,714 ounces of silver in 1915, against 2,753,953 ounces in 1914 and 2,127,171 ounces in 1913. Yavapai County produced 1,343,363 ounces of silver in 1915, against 786,917 ounces in 1914.

Mine production of silver in Arizona in 1915, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Cochise	22	865,215	1,842,559	326,117	340	29	432	3,034,714
Coconino	.....	.....	913	.....	.....	.....	.....	913
Gila	.....	2,353	323,434	2,839	.....	58	.....	328,684
Graham	.....	.....	294	3,188	.....	.....	.....	3,482
Greenlee	8	12,012	69,190	.....	.....	.....	.....	81,210
Maricopa	6	10,481	494	7	.....	.....	.....	10,988
Mohave	.....	44,137	5,639	1,982	63,785	.....	171,671	287,214
Pima	27	432	47,398	781	.....	7,243	.....	55,881
Pinal	3	7,002	411,782	4,317	.....	1,738	.....	424,842
Santa Cruz	6	28,984	21,374	13,249	422	4,699	.....	68,734
Yavapai	133	21,431	1,284,014	37,660	.....	125	.....	1,343,363
Yuma	104	2,137	3,419	3,304	.....	31	.....	8,995
	309	[a] 994,184	4,010,510	393,444	64,547	13,923	172,103	5,649,020

[a] Includes 71,909 ounces from gold ore, 82,571 ounces from gold and silver ore, and 839,704 ounces from silver ore.

COPPER.

A labor strike in the Clifton-Morenci district of Greenlee County slightly reduced the output of copper in Arizona in 1915. However, a record output of 459,972,295 pounds was made, valued at $80,495,152, in 1915, against 393,017,400 pounds, valued at $52,271,314, in 1914. Crude ore shipped directly to the smelters yielded 267,995,345 pounds, or about 58 per cent of the total quantity, against 233,047,975 pounds in 1914. Of the output from crude ore smelted in 1915 Cochise County produced about 63 per cent. Yavapai, Gila, and Greenlee counties also produced large quantities. The copper in concentrates produced at milling plants increased from 158,985,306 pounds in 1914 to 187,731,353 pounds in 1915. This increase was principally in Gila, Pinal, and Yavapai counties. Gila County, including the Globe and Miami districts, produced altogether 77,085,710 pounds in concentrates, against 73,488,162 pounds in 1914, 71,609,847 pounds in 1913, 63,969,423 pounds in 1912, and 49,226,341 pounds in 1911. The low-grade schist and so-called "porphyry" ores in Pinal and Gila counties yielded 124,264,911 pounds of copper, against 95,485,293 pounds in 1914, 87,073,406 pounds in 1913, 68,753,553 pounds in 1912, and 30,666,515 pounds in 1911. Similar low-grade copper deposits exist in Greenlee County, whose output added made the total production from the so-called "porphyries" in Arizona 164,483,500 pounds, or about 36 per cent of Arizona's copper output in 1915. In 1914 these ores altogether produced 152,555,064 pounds of copper.

Mine production of copper in Arizona in 1915, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Cochise	425,417	169,515,754	943,618	.....	2,463	560	170,887,812
Coconino	.....	66,774	.....	.....	.....	.....	66,774
Gila	5,348	103,554,670	272	.....	2,074	.....	103,562,364
Graham	.....	21,024	6,283	.....	.....	.....	27,307
Greenlee	470	51,095,755	.....	.....	.....	.....	51,096,225
Maricopa	18,591	25,669	.....	.....	.....	.....	44,260
Mohave	522	952,500	.....	.....	.....	45,649	998,671
Pima	162	3,545,344	1,217	.....	15,060	.....	3,561,783
Pinal	1,963	67,720,164	62	.....	3,529	.....	67,725,718
Santa Cruz	5,055	770,352	1,618	13,297	20,452	.....	810,774
Yavapai	29,789	59,196,137	2,595	.....	582	.....	59,229,103
Yuma	694	1,959,468	.....	.....	1,342	.....	1,961,504
	[a] 488,011	458,423,611	955,665	13,297	45,502	46,209	459,972,295

[a] Includes 57,761 pounds from gold ore, 395,922 pounds from gold and silver ore, and 34,328 pounds from silver ore.

LEAD.

The mine production of lead in Arizona in 1915 was 21,738,969 pounds, valued at $1,021,732, against 15,003,068 pounds, valued at $585,120, in 1914. Cochise County, principally the Warren or Bisbee district, had the largest yield of lead, or 13,129,004 pounds, valued at $617,063, as against 9,331,116 pounds, valued at $363,914, in 1914. Mohave County followed with 6,459,557 pounds and Santa Cruz County with 1,192,492 pounds. Concentrates derived from low-

grade ores produced 8,426,634 pounds of lead, and crude ores shipped directly to smelters produced 13,312,335 pounds.

Mine production of lead in Arizona in 1915, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Cochise	37,520	.....	13,084,553	.....	2,856	4,075	13,129,004
Gila	.....	.....	115,543	.....	9,213	.....	124,756
Graham	.....	.....	203,062	.....	.....	.....	203,062
Maricopa	193,527	.....	950	.....	.....	.....	194,477
Mohave	10,850	.....	38,632	350,000	.....	6,060,075	6,459,557
Pima	.....	.....	27,384	.....	30,440	.....	57,824
Pinal	.....	.....	33,642	.....	27,453	.....	61,095
Santa Cruz	14,899	1,011	1,124,854	.....	51,728	.....	1,192,492
Yavapai	48,928	.....	110,765	.....	2,057	.....	161,750
Yuma	.....	.....	153,469	.....	1,483	.....	154,952
	[a] 305,724	1,011	14,892,854	350,000	125,230	6,064,150	21,738,969

[a] Includes 255,334 pounds from gold ore and 50,390 pounds from silver ore.

ZINC.

The mine output of zinc (calculated as spelter) from Arizona zinc-bearing ores in 1915 amounted to 18,220,863 pounds, valued at $2,259,387, against 9,792,337 pounds, valued at $499,409, in 1914 and 9,428,067 pounds in 1913. Most of the zinc ore was mined in Mohave County at Union Pass and Chloride and was shipped to the smelters in the form of concentrates, which yielded 16,728,411 pounds of zinc. Smaller quantities of zinc ore were mined in 1915 in Cochise, Santa Cruz, Pima, Yavapai, and Pinal counties.

Mine production of zinc (spelter) in Arizona in 1915, in dry pounds.

County.	Dry or siliceous ore.	Zinc ore.	Lead-zinc ore.	Total.
Cochise	.....	63,386	24,319	87,705
Mohave	.....	9,011,276	8,371,573	17,382,849
Pima	.....	252,527	.....	252,527
Pinal	.....	16,620	.....	16,620
Santa Cruz	.....	432,582	.....	432,582
Yavapai	48,580	.....	.....	48,580
	48,580	9,776,391	8,395,892	18,220,863

Zinc ore and concentrate from Arizona mines and mills sold in 1915.

County.	Classification.	Quantity.	Average assay of ore and concentrate.[a]
		Short tons.	*Per cent of zinc.*
Cochise, Mohave, and Pima	Sulphide zinc ore	1,863	39.64
Cochise, Pima, and Pinal	Carbonate ore	428	32.84
Mohave, Santa Cruz, and Yavapai	Concentrates (sulphide)	25,476	38.63
Total ore and concentrates	.....	27,767	38.60

[a] Actual assay content.

MINING INDUSTRY.

Until the price of copper and other metals improved the first part of the year, conditions in 1915 were very much like those at the end of 1914. A labor strike, based on a demand for increased wages and recognition of the union, was called on September 11 in the Clifton-Morenci district. There was no settlement of this strike in 1915. In the other parts of the State labor conditions were satisfactory and wages were increased according to the market price for copper. Many old properties which had been closed for years were reopened and the opening of new properties was brought about by the high prices of the metals. The smelting companies doing a custom business were affected by this situation, and their plants were operated to capacity.

Transportation facilities showed little change. It is reported that several counties voted large bond issues for good roads, and motor-truck haulage is more used. Construction was started in August on the railroad branch, 43.5 miles long, connecting the mines at Ajo with Gila Bend, on the Southern Pacific main line, and the branch was completed connecting the Magma mine at Superior with the railroad at Webster, on the Arizona Eastern Railroad. The Mascot & Western Railroad, which connects the Mascot Copper property with the Southern Pacific at Willcox, was completed June 15. It is 15 miles long and is said to have cost $300,000. At the same time an aerial tramway 10,000 feet in length was completed between the mine and the loading bins at the railroad.

REDUCTION MILLS.

Various kinds of milling plants, to the number of 68, were in operation in Arizona in 1915, only a few continuously. Twenty-one mills used straight amalgamation; 7, amalgamation and concentration; 2, amalgamation and cyanidation; 14, only cyanidation; 1, concentration and cyanidation; 21, straight concentration, of which 5 were equipped with the oil flotation process; and 2, amalgamation, concentration, and cyanidation combined. A list giving all the mills in commission, including many new plants under construction in 1911 and some in 1912, was published in Mineral Resources for 1911.

In 1915 the ore treated by amalgamation amounted to 34,360 tons and produced 6,884.65 ounces of gold and 1,797 ounces of silver, an average recovery per ton of $4.14 in gold and 0.05 ounce of silver. Ores treated by cyanidation amounted to 266,916 tons, which, with 723 tons of old tailings, produced 86,080.07 ounces of gold and 739,781 ounces of silver, or an average recovery per ton for ore and tailings of $6.65 in gold and 2.76 ounces of silver. The total value of the bullion recovered from ore and tailings was $2,297,731, as against $2,757,371 in 1914. During 1915 there were 547 pounds of quicksilver, 715 pounds of potassium cyanide, and 226,427 pounds of sodium cyanide consumed at milling plants. This corresponds to 0.063 pound of mercury per ounce of gold and silver and 0.015 pound of mercury per ton of ore treated. The consumption of cyanide was 0.275 pound per ounce of gold and silver, and 0.85 pound per ton of ore and tailings treated.

Gold and silver produced at mills in Arizona in 1915.

County.	Ore.	Content of bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Cochise	125,065	82.52	19	8,501.28	688,608	$526,577
Gila	90	61.56	17	.....	.....	1,282
Greenlee	56	7.20	3	4.62	1	246
Maricopa	30,375	4,529.84	1,054	*a* 3,383.82	*a* 2,881	165,585
Mohave	136,295	50.98	18	72,953.48	37,549	1,528,182
Pima	22	.....	.....	12.06	28	263
Pinal	1,003	535.95	142	.....	.....	11,151
Santa Cruz	30	27.27	14	.....	.....	571
Yavapai	8,083	1,466.93	381	985.51	9,299	55,604
Yuma	257	122.40	149	*b* 239.30	*b* 1,415	8,270
	301,276	6,884.65	1,797	86,080.07	739,781	2,297,731

a Includes bullion from 598 tons of old tailings. *b* Includes bullion from 125 tons of old tailings.

Concentration plants reduced 6,606,759 tons of ore to 521,676 tons of concentrates, which were shipped to smelters and yielded $384,190 in gold, 910,138 ounces of silver, 187,731,353 pounds of copper (or more than 40 per cent of the total output of copper in the State), 8,426,634 pounds of lead, and 16,728,411 pounds of zinc (spelter), valued in all at $36,168,992, a total average value per ton of $69.31. Copper concentrates amounting to 482,268 tons comprised more than 92 per cent of the total concentrates produced.

Mine production of metals from Arizona concentrates in 1915.

By counties.

	Ore to concentrating mills.	Concentrates produced.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value of concentrates.
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Cochise	9,240	2,800	183.04	23,643	263,195	612,322	.....	$90,609
Gila	2,384,063	145,123	2,229.00	180,649	77,085,710	.....	.....	13,627,665
Greenlee	1,150,018	149,633	1,605.50	50,333	41,846,589	.....	.....	7,381,861
Maricopa	.....	953	5,438.66	6,130	17,527	193,527	.....	127,698
Mohave	69,207	34,188	4,824.68	228,995	45,649	6,414,074	16,247,249	2,539,945
Pinal	2,910,579	173,740	1,942.82	340,551	64,614,265	6,480	.....	11,520,622
Santa Cruz	7,373	2,727	20.51	11,131	13,564	1,092,707	432,582	113,438
Yavapai	75,919	12,467	2,340.99	67,191	3,844,854	48,777	48,580	763,625
Yuma	360	45	.....	1,515	.....	58,747	.....	3,529
	6,606,759	521,676	18,585.20	910,138	187,731,353	8,426,634	16,728,411	36,168,992

By kinds of concentrates.

Dry or siliceous	.....	109	114.15	5,718	1,613	.....	.....	$5,541
Copper	.....	482,268	7,722.73	627,659	187,637,795	.....	.....	33,314,480
Lead	.....	13,823	7,558.68	174,732	77,999	7,651,531	.....	618,112
Zinc	.....	25,476	3,189.64	102,029	13,946	775,103	16,728,411	2,230,859

Of the material smelted, the crude ore was the largest part—2,614,897 tons. It contained the following quantities of recoverable metals: 88,099.14 ounces, or $1,821,171 in gold; 3,945,730 ounces of silver; 267,995,345 pounds of copper; 13,312,335 pounds of lead; and 1,492,452 pounds of zinc, valued in all at $51,531,585, or an average value per ton of $19.71. Of the crude ores smelted, the copper ores constituted the largest part—2,558,301 tons, of which the Warren or Bisbee district, in Cochise County, produced nearly 61 per cent. The lead ores formed the next largest quantity—34,938 tons, followed by dry or siliceous ores—18,941 tons, the latter being produced largely in the Warren or Bisbee district of Cochise County.

Mine production of metals from Arizona crude ore shipped to smelters in 1915.

By counties.

	Crude ore to smelter.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Cochise	1,690,865	50,189.44	2,271,179	168,048,793	12,516,682	87,705	$32,196,695
Coconino	200	37.01	913	66,774	.....	.....	12,913
Gila	189,933	1,827.93	148,004	26,382,743	124,756	.....	4,735,668
Graham	323	4.98	3,482	27,307	203,062	.....	16,191
Greenlee	112,888	659.93	30,865	8,288,208	.....	.....	1,479,726
Maricopa	150	67.48	917	26,733	950	.....	6,583
Mohave	7,294	837.47	20,644	953,022	45,483	1,135,600	337,509
Pima	35,372	190.44	55,826	3,561,783	57,824	252,527	689,584
Pinal	17,057	407.48	84,146	3,111,453	54,615	16,620	600,216
Santa Cruz	4,457	247.11	57,583	797,210	99,785	.....	178,506
Yavapai	527,841	32,841.07	1,266,359	54,769,815	112,973	.....	10,910,957
Yuma	28,517	788.80	5,812	1,961,504	96,205	.....	367,037
	2,614,897	88,099.14	3,945,730	267,995,345	13,312,335	1,492,452	51,531,585

By kinds of ore.

Dry or siliceous	18,941	4,982.89	178,886	451,271	20,714	.....	$273,647
Copper	2,558,301	80,186.26	3,381,334	266,557,055	1,011	.....	50,019,466
Lead	34,938	2,492.29	362,465	940,957	13,126,305	.....	1,016,893
Zinc	2,258	334.00	8,690	.....	35,000	1,468,133	195,003
Copper-lead	426	103.37	13,923	45,502	125,230	.....	23,045
Lead-zinc	33	.33	432	560	4,075	24,319	3,531

SMELTING.

During 1915 smelter construction was devoted to increasing the capacity of existing plants rather than to any new work, though work on the new plants—the International, at Miami, and the United Verde, at Clarkdale—was begun. The following condensed data relating to the equipment of smelting plants in the State of Arizona, compared with similar data published in Mineral Resources for 1913, page 681, show the increasing use of reverberatory furnaces in the newer plants:[1]

[1] Douglas, James, Equipment of Arizona smelters: Met. and Chem. Eng., Dec. 1, 1915, p. 904.

Smelting plants for copper ore in Arizona in 1915.

Name.	Location of plant.	Principal equipment.
Cochise County:		
Copper Queen	Douglas	10 blast furnaces, 3 reverberatories, 7 converters, 16 roasters.
Calumet & Arizona	do	2 blast furnaces, 4 reverberatories, stands for 6 converters (Great Falls type), 12 roasters.
Greenlee County:		
Arizona Copper	Clifton	4 reverberatories, 6 roasters, 6 converter stands.
Detroit	Morenci	1 large blast furnace and 4 small converters.
Shannon	Clifton	3 blast furnaces and 2 stands of converters.
Gila County:		
Old Dominion	Globe	6 cupola furnaces and 2 converters.
American	Hayden	2 reverberatories, 8 roasters, 3 converters.
International	Globe	3 reverberatories, 6 roasters, 6 converters.
Yavapai County:		
Consolidated Arizona	Humboldt	2 reverberatories, 1 Wedge roaster, 2 converters.
United Verde	Jerome	4 blast furnaces, 4 reverberatories, 6 roasters, 5 converters.

Ore sold or treated, number of deep mines producing, and average values of ore per ton in Arizona in 1914 and 1915.

County.	Ore sold or treated.		Number of deep mines producing.		Average total value per ton.[a]		Average value per ton in gold and silver.[a]	
	1915	Increase or decrease.	1914	1915	1914	1915	1914	1915
	Short tons.	*Short tons.*						
Cochise	1,888,435	+ 293,050	45	65	$14.78	$17.63	$1.59	$1.46
Coconino	200	+ 137	1	2	42.87	64.56	1.35	6.14
Gila	2,575,649	+1,061,849	25	52	6.59	7.14	.13	.10
Graham	323	+ 267	3	7	30.12	50.13	2.02	5.78
Greenlee	1,266,899	− 417,582	13	28	5.19	7.13	.01	.07
Maricopa	31,123	− 8,317	12	22	14.39	9.63	13.89	9.09
Mohave	227,435	+ 23,431	43	35	13.33	19.37	9.73	7.79
Pima	35,394	+ 25,737	28	49	18.60	19.49	2.92	.92
Pinal	2,928,639	+ 466,180	27	46	3.32	4.14	.06	.09
Santa Cruz	14,360	+ 1,537	34	27	31.96	20.37	6.02	2.85
Yavapai	614,843	+ 154,861	81	89	11.99	19.25	2.13	2.37
Yuma	29,259	+ 1,482	26	46	2.14	12.95	1.30	.97
	9,612,559	+1,602,632	338	468	7.49	9.44	.82	.73

[a] Value per ton, placer product excluded.

REVIEW OF MINING INDUSTRY BY COUNTIES.

Mine production of metals in Arizona in 1915.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total value.		
	Quantity.	Value.	Quantity.	Value.		Quantity.	Value.
	Fine ounces.		*Fine ounces.*			*Fine ounces.*	
Cochise	86.01	$1,778	59,119.28	$1,222,104	$1,223,882	3,034,714	$1,538,600
Coconino	.....	.....	37.01	765	765	913	463
Gila	.....	.....	4,120.49	85,178	85,178	328,684	166,643
Graham	.....	.....	4.98	103	103	3,482	1,765
Greenlee	39.14	809	2,277.25	47,075	47,884	81,210	41,173
Maricopa	48.28	998	13,419.80	277,412	278,410	10,988	5,571
Mohave	.....	.....	78,678.89	1,626,437	1,626,437	287,214	145,618
Pima	127.52	2,636	202.50	4,186	6,822	55,881	28,332
Pinal	29.31	606	2,886.25	59,664	60,270	424,842	215,395
Santa Cruz	24.48	506	294.89	6,096	6,602	68,734	34,848
Yavapai	672.89	13,910	37,634.50	777,974	791,884	1,343,363	681,085
Yuma	677.49	14,005	1,150.50	23,783	37,788	8,995	4,560
	1,705.12	35,248	199,826.34	4,130,777	4,166,025	5,649,020	2,864,053

Mine production of metals in Arizona in 1915—Continued.

County.	Copper.		Lead.		Zinc (spelter).		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Cochise	170,887,812	$29,905,367	13,129,004	$617,063	87,705	$10,876	$33,295,788
Coconino	66,774	11,685	.....	.....	.....	.....	12,913
Gila	103,562,364	18,123,414	124,756	5,864	.....	.....	18,381,099
Graham	27,307	4,779	203,062	9,544	.....	.....	16,191
Greenlee	51,096,225	8,941,839	.....	.....	.....	.....	9,030,896
Maricopa	44,260	7,746	194,477	9,140	.....	.....	300,867
Mohave	998,671	174,767	6,459,557	303,599	17,382,849	2,155,473	4,405,894
Pima	3,561,783	623,312	57,824	2,718	252,527	31,313	692,497
Pinal	67,725,718	11,852,001	61,095	2,872	16,620	2,061	12,132,599
Santa Cruz	810,774	141,886	1,192,492	56,047	432,582	53,640	293,023
Yavapai	59,229,103	10,365,093	161,750	7,602	48,580	6,024	11,851,688
Yuma	1,961,504	343,263	154,952	7,283	.....	.....	392,894
	459,972,295	80,495,152	21,738,969	1,021,732	18,220,863	2,259,387	90,806,349

COCHISE COUNTY.

Mine production in Cochise County, Ariz., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.	*Value.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	46	1,595,385	$1,014,675	2,753,953	155,420,887	9,331,116	122,304	$23,578,741
1915	67	1,888,435	1,223,882	3,034,714	170,887,812	13,129,004	87,705	33,295,788
Increase or decrease, 1915		+293,050	+209,207	+280,761	+15,466,925	+3,797,888	—34,599	+9,717,047

[a] Includes small placer production.

The total average value per ton of the ore increased from $14.78 in 1914 to $17.63 in 1915, and the gold and silver value in this ore decreased from $1.59 to $1.46. All of the metals with the exception of zinc, which was less in quantity, showed an increase in quantity and value. Gold, valued at $1,014,675 in 1914, increased to $1,223,882 in 1915; silver, from $1,522,936 in 1914 to $1,538,600 in 1915; copper, from $20,670,978 in 1914 to $29,905,367 in 1915; lead, from $363,914 in 1914 to $617,063 in 1915. Zinc, estimated as spelter, which had a value of $6,238 in 1914, increased to $10,876 in 1915. Ores of smelting grade, of which there were 1,690,865 tons, predominated and contained $1,037,508 in gold, 2,271,179 ounces of silver, 168,048,793 pounds of copper, 12,516,682 pounds of lead, and 87,705 pounds of zinc, valued in all at $32,196,695, or an average value per ton of $19.04. The 33,829 tons of lead ores shipped to lead plants outside of the State contained 2,320.14 ounces of gold, 313,157 ounces of silver, 929,177 pounds of copper, and 12,507,786 pounds of lead. Of the copper ores smelted, it was estimated that 112,160 tons were oxidized ores and 1,528,388 tons were sulphide ores. Two producers reported some placer gold.

California district.—Five producers reported the output of 174 tons of ore shipped directly to smelters, containing 1,076 ounces of silver, 4,977 pounds of copper, and 83,039 pounds of lead, valued in

all at $5,320, or an average value per ton of $30.57. The larger part of the ore was from the Sunset group and the remainder from the Garden, Blue Bell, and Leadville properties.

Cochise or Johnson district.—Ten producers reported 44,636 tons of ore, nearly all of which was shipped directly to the smelters and contained $80 in gold, 39,755 ounces of silver, 3,815,538 pounds of copper, and 13,269 pounds of lead, valued at $688,579, or an average value per ton of $15.43. In 1914 the output aggregated 20,507 tons, with a total value of $307,578. The largest shipments of copper sulphide ore were made from the Mammoth and Republic properties; the Copper Chief, Peabody, Texas, and Centurion properties were also producers. The Middlemarch property also produced some copper and the output is included in this district.

Dos Cabezas district.—The output of five deep mines and the bullion from surface mines was valued at $61,243. The largest producer was the Mascot property, which yields copper sulphide ore. A large amount of development work was done on this property, which is opened by a vertical shaft 400 feet deep and an adit 2,200 feet long. In 1915 about 6,000 feet of development work was done, and the Oregon shaft was connected with the Consolidated adit. The Henry Clay and Casey properties also produced some ore containing principally gold.

Hartford or Huachuca district.—Altogether 151 tons of ore were produced from nine mining properties; the principal shipments came from the Nellie James claims and consisted of lead-zinc sulphide ore carrying a little copper and silver. The Black Bear and Copper King mines were also producers. The Two Peaks property, situated in the Whetstone Mountains, produced copper oxidized and sulphide ore.

Tombstone district.—Eight producers had an output in 1915 of 9,003 tons of ore, containing $25,135 in gold, 100,115 ounces of silver, 36,075 pounds of copper, 164,136 pounds of lead, and 63,386 pounds of zinc, valued in all at $97,780, or an average value per ton of $10.86. Various kinds of ore were treated at the mill of the Bunker Hill Mines Co., which was the principal producer. In the various mines exploration work in 1915 was done principally on the claims tributary to the shafts of the Bunker Hill property, known as the Flora Morrison, Grand Central, Telephone, Bunker Hill, Silver Plume, Oregon, Lucky Cuss, Tribute, West Side, Toughnut, Silver Thread, and Tranquillity. This company is avoiding the task of pumping the enormous flow of water that wrecked the old company and has been blocking out gold-silver-lead ore above the water level in the Tranquillity-Toughnut-Contention section, and has uncovered numerous bodies of wulfenite. For the treatment of low-grade gold-silver ores 30 stamps are used and a cyanide mill equipped for percolation of sands and agitation of slimes. In the Escondido, Lucky Cuss, Oregon, and Prompter mines manganese ores have been opened, high-grade ore has been shipped as chemical ore, some of the lower grade as "furnace" ore, and some concentrated. The concentrates are graded as chemical ore, and the tailings, containing about 10 ounces of silver per ton, are shipped as flux to the Copper Queen

smelter at Douglas. The company's[1] annual report contains further information, as follows:

> Operations on the upper levels of the Bunker Hill Mines Co. have not as yet developed ore bodies of great size or commercial importance. The low-grade material which has been opened up in the mines has been thoroughly tested by both cyaniding and concentrating, with inconclusive results. A profitable market now exists for the manganese ores which occur so generally through some sections of the property, and advantage will be taken of the present high price for this mineral to ship heavily of both ore and concentrates.

Shipments of silver ore were made from the Royal Guard and Solstice properties, and discovery of sulphide zinc ore was reported from the San Juan group, from which test shipments were made that carried 40 per cent of zinc and 8.5 ounces of silver per ton. This property is situated 13 miles northwest of Tombstone, in the Horstman Basin. The ore was recently discovered and is said to occur in a contact metamorphic deposit. The greatest development of ore occurs as a lenticular mass in the first thick-bedded limestone, which is very much altered.

Turquoise district.—There were 167,053 tons of ore and old tailings mined in the district by 13 producers in 1915, which yielded $178,973 in gold, 729,996 ounces of silver, 2,048,016 pounds of copper, and 55,065 pounds of lead, valued in all at $910,072, or an average value per ton of $5.45. The greater part of the ore was treated in the mill at the Commonwealth mine, producing gold and silver bullion. This mine is opened by two incline shafts, 517 and 600 feet deep. It is equipped with a 330-ton stamp mill and cyanide plant, in which the equipment consists of Hardinge tube mills for fine grinding. The pulp is agitated, thickened, and filtered in Oliver filters. The mine and mill were operated almost continuously during 1915. Two centrifugal pumps, with a combined capacity of 1,500 gallons per minute, were installed at the mine, and during the year an average flow of 2,000,000 gallons of water per day was pumped.

The largest output of copper sulphide ore came from the Copper Belle property and was used for fluxing at the Shannon smelter near Clifton. The Mary and Mamie, Copper Rocks, Germania, and Maid of Sunshine properties also produced copper ore, most of which was oxidized.

Warren or Bisbee district.—The mines of the district, reported by 15 producers, yielded 1,662,249 tons of ore, containing $1,013,899 in gold, 2,157,478 ounces of silver, 164,667,175 pounds of copper, and 12,807,180 pounds of lead, valued in all at $31,526,433, or an average value per ton of $18.97. Most of the ore produced was of smelting grade and aggregated 1,606,886 tons, consisting principally of copper ore, which was treated at Douglas, Ariz., and lead ore, which was treated at El Paso, Tex.

At the Copper Queen mines[1] oxidized and sulphide copper ores and silver-lead ores were produced in 1915. Altogether 783,211 tons of crude ore were shipped to smelters at Douglas and Globe, Ariz., and El Paso, Tex. Of the total, 23,138 tons were lead ore. In addition, 1,359 tons of copper concentrates were sent to Douglas, and 971 tons of lead concentrate to El Paso, also 601 tons of copper precipitates and 46,965 tons of old dump slag. The total content of these

[1] Phelps, Dodge & Co. Ann. Rept. for year ending Dec. 31, 1915.

shipments was 18,974 ounces of gold, 943,368 ounces of silver, 88,551,180 pounds of copper, and 9,388,418 pounds of lead. The annual report of Phelps, Dodge & Co. gives further information concerning the Copper Queen mine as follows:

At the mines of the Copper Queen continued and systematic development by churn drilling has extended the previously discovered bodies of disseminated ores so considerably as to assure many years' supply for a large concentrator. The copper contents of this ore is above the average of similar deposits now being profitably exploited and the percentage of recovery, as demonstrated by the experimental mill operated throughout the year, is eminently satisfactory. * * *

The ore extracted from the mine, 783,211 tons, exceeded the previous year's production by 62,468 tons, while the metal content, exclusive of slag dump recoveries, exceeded the year 1914 by 762,287 pounds of copper, 499,243 pounds of lead, 3,205 ounces of gold, but fell off 96,785 ounces of silver. * * *

The increase in the Sacramento Hill ore has been most gratifying, especially the extension recently discovered of the East End ore to the west, though its extraction may endanger the Sacramento shaft and the power house.

Tests on a working scale in the experimental mill have demonstrated that 1.3 per cent of copper will make ore and it is probable that 1 per cent material can be worked.

Percentage of product mined by different systems at the Copper Queen mines, 1913–1915.

Year.	Square set.	Top slicing.	Cut and fill.	Shrinkage.
	Per cent.	*Per cent.*	*Per cent.*	*Per cent.*
1913	88.1	2.8	8.4	0.7
1914	76.1	13.9	8.2	1.8
1915	65.9	18.7	15.2	.2

The methods of mining have not changed except in the proportionate quantities mined by different systems. The replacement of the square set method of mining by the more recent devices has notably reduced the cost.

The working conditions in the three divisions where forced ventilation has been introduced have demonstrated that better ventilation and lower temperature have been elements in the reduction of cost of mining.

Since the fire at the Holbrook, tailings water from the cementation plant has been pumped to the Holbrook and used for irrigating some of the old stopes. The copper contents of the water has thus been increased, and the precipitating plant has made a good saving.

The Calumet & Arizona Mining Co.[1] completely absorbed the interests of the Superior & Pittsburg Copper Co., causing the dissolution of that organization on December 31, 1915. The combination brings under one management approximately 2,000 acres of ground within the mineralized zone of the district. The Calumet & Arizona Mining Co. also operates a smelter at Douglas, which receives some custom ore. Dividends were paid in 1915 aggregating $2,006,557. The following extracts are taken from the company's printed report:

For the first three months of the year we operated under the 50 per cent curtailment put in effect in August, 1914. Production was gradually increased in April and May and June operations were running at normal again. In December 72,419 tons of ore were mined. This is the largest tonnage ever shipped from our Bisbee mines in a single month up to that time.

We started development on various surface and underground lead-silver ore streaks this year from which a total of 1,793 tons was shipped to the El Paso smelter at a good profit. * * *

[1] Calumet & Arizona Mining Co. Ann. Rept. for year ending Dec. 31, 1915.

One of the most gratifying results of the year's work was the further increase of our ore reserves of 366,551 tons over our reserves of December 31, 1914, although we mined and shipped 729,677 wet tons of ore. The average copper contents also showed a slight increase.

The total amount of development work done during the year 1915 was 93,788.5 feet, as compared with 72,793 feet in 1914. * * *

The most important development of the year at this mine (Junction) was the expansion of the ore mentioned last year on the Rathmoon claim, where connection between the Junction and Briggs shafts was made on the 1,300 level. The ore was originally sulphide, but has developed into a fine body of mixed oxide and sulphide ore of good grade. It has been developed 150 feet square and is still extending. A few hundred feet north from here, on the Rathmoon and Oakland claims, have been found a series of small lenses of sulphide ore, on the 1,300 and 1,400 levels, which total into a large tonnage. * * *

At this mine (Briggs) the big sulphide ore body just east of the shaft has been nearly exhausted above the 1,300 level, and we are now mining below that level with satisfactory results. * * *

According to a late report[1] on the geology of the district, the oxidized lead ores in recent years have become more and more important, especially from around highly siliceous replacements in Martin and Escabrosa limestones. Most of this ore has come from the Southwest mine and occurs at the edge of the siliceous breccia, as cerusite with some anglesite and variable values in silver and gold. Lead ores have also been found with similar associations in the Gardner, Lowell, and Briggs mines.

From the Shattuck-Arizona mine[2] there were smelted at Douglas 94,591 dry tons of copper ore and at El Paso, Tex., 7,800 dry tons of lead ore, which produced 11,154,211 pounds of copper, 3,151 ounces of gold, 201,869 ounces of silver, and 2,345,342 pounds of lead. The property is developed to the 900-foot level, which is yielding semi-oxidized copper ore. Statements from the company's annual report are as follows:

The copper market continuing unsatisfactory at the beginning of the year, it was advisable to prosecute development work only from January 1, 1915, until better copper conditions prevailed; therefore, during that period no shipments of copper ore were made to the smelter. Ore shipments to the smelter were resumed March 30, 1915, at the rate of 250 tons daily, and from that date the ore output was gradually increased to full capacity, the output at the close of the year being 550 tons daily of all ores. * * *

Our siliceous gold and silver ores carrying low values in copper have developed into more importance during the year, both in tonnage and value. These ores are found in irregular pockets between the 100 and 600 foot levels. * * *

Shipments of lead ore have been made at the rate of 50 tons daily since June 20, 1915. * * * We have opened up and blocked out good tonnages of lead ores between the 500 and 600 foot levels in the past 12 months. These lead ore bodies for the most part are separate and distinct from our copper ore bodies, and therefore do not interfere with copper ore production. * * *

The experimental work conducted on a small scale on the complex ores of lead, copper, and vanadium shows that we can obtain an extraction of not less than 90 per cent of the vanadium contents of the ore, and in addition recover the lead and copper contained. * * *

Lessees operated the Twilight group, producing copper sulphide ore carrying values in gold and silver, and the Wolverine & Arizona property was operated the entire year, yielding copper sulphides. There was also a small production of ore of shipping grade containing gold, silver, and a little copper, from the Juniper Flats property.

[1] Bonillas, Y. S., Tenney, J. B., and Fenchere, Leon, Geology of the Warren mining district: Am. Inst. Min. Eng. Monthly Bull. 117, p. 9461, September, 1916.

[2] Shattuck-Arizona Copper Co. Ann. Rept. for year ending Dec. 31, 1915.

COCONINO COUNTY.

Reports received from two producers gave a production of 200 tons of copper ore, containing a small quantity of gold and silver, all of which was produced in the Francis and Grand Canyon districts.

Francis district.—A small quantity of oxidized copper ore was shipped from the Anita and Emerald properties.

Grand Canyon district.—Copper sulphide ore carrying a little gold and silver was shipped from the Grand Canyon copper property by lessees.

GILA COUNTY.

Mine production in Gila County, Ariz., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.	*Value.*	*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	27	1,513,800	[a] $44,535	[a] 272,907	73,488,162	21,575	$9,970,219
1915	52	2,575,649	85,178	328,684	103,562,364	124,756	18,381,099
Increase, 1915		1,061,849	40,643	55,777	30,074,202	103,181	8,410,880

[a] Includes small placer production from 2 mines.

The total average value per ton of the ore sold or treated in Gila County increased from $6.59 in 1914 to $7.14 in 1915, and the gold and silver value per ton decreased from 13 cents to 10 cents. There were increases in the value of all of the metals. Gold was valued at $85,178, an increase of $40,643 compared with 1914; silver increased in value from $150,917 to $166,643; copper from $9,773,926 to $18,123,414; and lead from $841 to $5,864. Of the ores produced, 2,384,063 tons were of concentrating grade and produced 145,123 tons of concentrate, containing 2,229 ounces of gold, 180,649 ounces of silver, and 77,085,710 pounds of copper. The crude ores, mostly copper ore, shipped directly to the smelters amounted to 189,933 tons, against 178,068 tons in 1914. The crude ores in 1915 contained 1,827.93 ounces of gold, 148,004 ounces of silver, 26,382,743 pounds of copper, and 124,756 pounds of lead. There were also 1,563 tons of old slag containing copper resmelted. Nearly all of this ore was treated in the district, with the exception of the lead ores and some copper ores, which were shipped to plants outside of the county. Of the copper ores smelted, 159,900 tons were oxidized and 29,313 tons were sulphides. The smelting ores shipped were valued at $4,735,668, or an average value per ton of $24.93, and the concentrates, chiefly copper, were valued at $13,627,665, or an average value per ton of $93.91.

Banner district.—The output in 1915 from 12 properties (6,059 tons) was double the production of 1914, when four deep mines produced 3,191 tons of ore. The output in 1915 contained $15,679 in gold, 6,974 ounces of silver, 641,989 pounds of copper, and 101,391 pounds of lead, valued in all at $136,329, or an average value per ton of $22.50. The Snyder and Gila copper properties shipped equal quantities of copper ore, most of which was oxidized. The O'Carroll group also produced oxidized copper ore containing a little silver.

Dripping Springs district.—Two producers reported the production of 24 tons of ore with a total value of $2,976, or an average value per ton of $124. The ore from one property contained principally gold and from the other copper.

Globe district.—Thirty-six producers reported the production of 2,569,508 tons of ore, which is chiefly the output of 9 large properties. Most of this ore (2,384,063 tons) was concentrated and yielded 145,123 tons of copper concentrate, containing 2,229 ounces of gold, 180,649 ounces of silver, and 77,085,710 pounds of copper. The ore smelted directly amounted to 183,852 tons and contained 998.58 ounces of gold, 140,939 ounces of silver, 25,734,812 pounds of copper, and 23,365 pounds of lead. The lead came from two properties in the district and was shipped outside of the State. There were 1,563 tons of old slag resmelted containing 93,911 pounds of copper.

In 1915 the Old Dominion mine[1] produced 115,459 tons of ore, yielding 13,771,681 pounds of fine copper, 40,633 ounces of silver, and 620.96 ounces of gold. There were milled 32,380 dry tons of ore, which assayed 3.72 per cent of copper, as compared with 30,159 tons assaying 4.69 per cent in 1914. The smelting ore amounted to 80,512 tons, averaging 7.81 per cent of copper in 1915, as compared with 99,507 tons of 8.28 per cent grade in 1914. Of the siliceous copper ore, 2,567 tons averaged 3.65 per cent of copper, compared with 147 tons, averaging 3.12 per cent of copper in 1914. According to the printed report, the most important part of the mine's production continued to come from the "West Side" ore bodies, which yielded about three-quarters of the total quantity of smelting ore extracted. Other levels down to the seventeenth level maintained their output of ore. On the seventeenth level in block 7 the ore body is approximately 35 feet wide and was developed for a distance of 90 feet. On the eighteenth level this ore was cut for 40 feet, 18 feet of which was of good grade. All of the ore so far discovered on the seventeenth and eighteenth levels west has been concentrating ore. The "Central" ore bodies above the eighth level continued to furnish a small quantity, mostly from the old stopes, and the levels from the ninth down to the fifteenth have also been productive. The "East Side" ore bodies produced mainly from the western extension of the Gladiator ore body from the fourteenth to the sixteenth level. During 1915 there were pumped from the mine 2,769.4 million gallons of water, compared with 1,349.21 million gallons in 1914. Some of the water was sold to the Miami Copper Co. The minimum rate of flow during 1915 was 5,360,147 gallons in 24 hours on October 28, and the maximum was 14,492,923 gallons in 24 hours on March 26. In the concentration plant very satisfactory work was reported with oil flotation. By the recent improvements in the concentrator a gratifying increase was made in the total copper recovery from 73.55 per cent in 1914 to 85.27 per cent in 1915. The smelter on the property treats some custom ore, which, with the copper ore and concentrates from the mine and mill, yielded 13,868 tons of fine copper at the cost of $5.36 per ton.

At the United Globe mines[1] ore extraction and development were confined to the Old Dominion, Grey, and Buffalo veins. The quantity and grade of ores extracted and shipped in 1915 compare as follows with the previous year:

[1] Old Dominion Copper Mining & Smelting Co. Ann. Rept. for year ending Dec. 31, 1915.

Ore produced from United Globe mines, 1914 and 1915.

Kind of ore.	1914		1915	
	Tons.	Per cent.	Tons.	Per cent.
Smelting oxide	14,352	6.38	19,112	6.90
Smelting sulphide	12,640	1.69	292	1.01
Concentrating ore	121,811	3.23	119,537	3.63
Silica converter lining	6,402	7.44	2,299	4.73
	155,205	3.57	141,240	4.08

Extracts from the company's printed report are as follows:

The ore body discovered last year in blocks 47–49 between the tenth and twelfth levels was developed very satisfactorily during the past year, showing a maximum width of 45 feet. Vertically it has been developed to the seventh or Grey level, 100 feet above. Almost the entire production of the tenth level for the year has been from this ore body. The main drift on the tenth level has been advanced east to a point in block 53 opposite the Grey shaft. On the twelfth level the ore production has come mostly from blocks 35 and 36. A new development on this level is in blocks 41–43, where ore ranging in width from 3 to 8 feet has been opened up for a distance of 215 feet. This is a good grade of chalcocite ore and has been proved to extend 50 feet above and 100 feet below the twelfth level. The fourteenth level production has been maintained very satisfactorily. The production of ore on the fifteenth level has been increased very materially above that of the previous year, being 30,000 tons, compared with 7,000 tons in 1914. The vein has been opened through blocks 35, 36, 37, and 38 for a distance of 360 feet, in which distance it obtained a maximum width of 40 feet. * * *

The Kingdon shaft is being sunk from the fourteenth to the sixteenth level. This will permit the shaft to be used for hoisting and ventilating purposes down to the present lowest operating level of the mine and will greatly facilitate mining operations on the east side. * * *

At the Miami[1] property 1,348,122 tons of ore, averaging 2.17 per cent of copper, were concentrated at the mill to 52,539 tons of concentrates, averaging 41.91 per cent of copper, representing an extraction of 75.17 per cent. The concentrate contained 44,033,761 pounds of copper, from which 41,832,059 pounds of refined copper was produced at the smelter. The total cost of handling the ore was $1.8785 per ton, divided into mining $1.0158, milling $0.5794, and general expense $0.2833, or a total average per pound of copper of $0.060538. There was very little change in the ore in reserve compared with that reported in 1914. Extracts of the company's annual report follow:

In the early months of the year operations were being conducted on a reduced scale inaugurated in the fall of the previous year. Beginning with the second quarter, the tonnage handled was increased and copper production rose until with the month of July slightly over 4,000,000 pounds was made, and at this rate was continued throughout the balance of the year.

The mill improvements started during 1914 were continued without seriously interfering with operations, and the last section was finished during the month of August. The results expected from these changes as to greater tonnage capacity and increased metallurgical efficiency have been realized.

The mine has responded with no difficulty to the demand for the larger tonnage, and is now turning out considerably above the estimated figure of 4,200 tons per day.

Copper production became important at the Inspiration mine[2] in June, 1915. The first ore was caved underground and actual mining

[1] Miami Copper Co. Ann Rept. for year ending Dec. 31, 1915.
[2] Inspiration Consolidated Copper Co. Ann. Rept. for year ending Dec. 31, 1915.

started July 25. Additional units to the milling plant were put into commission as fast as they reached completion. By the end of the year 12 units out of the total of 18 were in use. The copper production steadily increased from 1,095,000 pounds in July to 5,541,140 pounds in December, and the total for the period was 20,445,670 pounds of refined copper. Extracts taken from the company's report are as follows:

The tons of ore concentrated for the six months were 778,851.

	Percentage of copper.
Assay of ore milled	1.702
Oxide copper in ore	.226
Assay of tailings	.373
Oxide copper in tailings	.18
Assay of concentrates from flotation	37.63
Assay of concentrates from tables	13.12
Average assay of concentrates; total made	32.67
Average recovery of total copper in ores milled	79.95
Average recovery of sulphide copper in ores milled	88.56

Twenty-four and six-tenths tons of ore were required to produce 1 ton of concentrates.

The ore treated all came from underground work except 7,858 tons reclaimed from the Joe Bush and Scorpion dumps. The net copper deliverable by the Smelting Co. derived from the ores treated during the six months' period, July 1 to December 31, was as follows:

	Pounds.
From concentrating ores	20,067,310
From oxide ore sent direct to smelter	378,360
	20,445,670

The cost of copper derived from concentrating ores was:

	Cost per pound.	Cost per ton of ore.
	Cents.	
Mining	2.644	$0.68110
Coarse crushing	.113	.02910
Ore hauling	.079	.02025
Concentrating and royalty	1.889	.48675
Concentrate hauling	.006	.00160
	4.731	1.21880
Smelting, freight, refining, marketing, etc	3.455	.7642
	8.186	1.9830

The mining cost per ton of ore above includes a charge of 20 cents, which it is calculated will cover the average amount of drifts, raises, and haulage ways required per ton of ore mined. * * *

The saving of 88.56 per cent of sulphide copper in the new mill for the last six months of 1915 was on an ore that averaged 1.702 per cent total copper, of which 0.226 per cent was in oxide combination. We apparently saved about 24 per cent of this oxide copper and the resulting average saving of total copper contents of the ore milled in the new mill was 79.95 per cent. * * *

The test mill ran from January 3, 1914, to June 30, 1915, and treated 257,272 tons of ore. From the latter date until February 8, 1916, it operated as a temporary unit in our general concentrating process, when it was closed down, having treated 373,705 tons in total.

On the Copper Hill and Eureka mines[1] operations in 1915 were confined to ore extraction, exploration, and development. Altogether there were 44,353 tons of ore mined, averaging 4.872 per cent of

[1] Arizona Commercial Mining Co. Ann. Rept. for year ending Dec. 31, 1915.

copper. The ore of smelting grade amounted to 23,339.9 tons, averaging 5.407 per cent of copper, and the concentrating ore, which was 20,373.9 tons in quantity, averaged 4.171 per cent of copper. There were also produced 639 tons of siliceous ore, averaging 7.699 per cent of copper. The Copper Hill mine is developed to the fourteenth level, but most of the ore, or 32,000 tons, came from the thirteenth level, and 6,700 tons were produced from the fourteenth level.

Green Valley district.—Two properties produced bullion. The principal producer was the Arctic claim, near Payson, which produced its bullion by the amalgamation process in a 2-stamp mill. This mill has a concentrator which was not used in 1915

GRAHAM COUNTY.

Seven producers reported 323 tons of ore containing gold, silver, copper, and lead, valued at $16,191. All this ore was of smelting grade and was produced principally from the Aravaipa district.

Aravaipa district.—The ore shipped from this district in 1915 was of smelting grade and aggregated 226 tons, containing gold, silver, copper, and lead, valued at $12,272, or an average of $54.30 per ton. The principal producer was the Grand Reef property, operated by lessees.

Bunker Hill district.—Two producers on the Graham County side of the district shipped some copper ore containing silver and having a total average value per ton of $97.13. Most of the ore was taken from shallow workings. The largest part of the mine holdings in this district are the property of the Copper Creek Mining Co., whose principal holdings are on the Pinal County side.

Lone Star district.—Three producers of copper sulphide ore made an output of 81 tons, containing gold, silver, and copper, with an average value per ton of $29.20.

GREENLEE COUNTY.

Mine production in Greenlee County, Ariz., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Total value.
		Short tons.	*Value.*	*Fine oz.*	*Pounds.*	
1914	16	1,684,481	$20,045	11,711	65,558,501	$8,745,802
1915	34	1,266,899	47,884	81,210	51,096,225	9,030,896
Increase or decrease, 1915		−417,582	+27,839	+69,499	−14,462,276	+285,094

[a] Includes placer production.

There were 28 producers of ore and 6 producers of placer bullion in the county in 1915. The quantity of ore mined, however, was 417,582 tons less than was reported by 13 producers in 1914. The ore sold or treated averaged $7.13 per ton in 1915, against $5.19 in 1914. There was more gold and silver reported as being recovered from the refining of copper bullion than for any previous year, though these values amounted to only a few cents per ton. The concentrating ores aggregated 1,150,018 tons and produced 149,633 tons

of concentrates, which contained $33,189 in gold, 50,333 ounces of silver, and 41,846,589 pounds of copper, valued in all at $7,381,861, or an average value per ton of $49.33. The ore smelted was 112,888 tons, all of which was oxidized except 85 tons. Of this total, 112,166 tons were copper ore. The gold output of the placers amounted to $809 against a production of $2,268 in 1914.

Copper Mountain and Greenlee districts.—The production from the Detroit mines[1] aggregated 372,710 tons of ore of an average grade of 2.829 per cent of copper. Of this tonnage, 361,970 tons were milling ore at an average grade of 2.694 per cent. From the annual report of Phelps, Dodge & Co. the following extracts are taken:

A distribution of this tonnage over the various mines and into different classes is as follows:

Mine.	Total.	Second class.	Oxide.	Quartz.	Talc.	Sulphide.
Ryerson	165,653	164,549	.....	.....	.....	1,104
Yankie	83,705	83,298	.....	.....	.....	407
Copper Mountain	93,084	89,412	3,256	.....	.....	416
Arizona Central	29,820	24,711	.....	4,911	79	119
All other sources	448	.....	.....	.....	.....	448
	372,710	361,970	3,256	4,911	79	2,494

The new methods of mining and the extended use of machine drills increased the tonnage mined per man. Still further improvements alone justify the hope that lowering costs will allow lower grades of ore being attacked. * * *

The production from the leaching plants amounted to 137,400 pounds copper cement of an average grade of 51.862 per cent copper, containing 70,740 pounds of copper. The company took over these plants late in 1914, and since then they have been entirely remodeled, but it is confidently expected that leaching methods will be devised by which a large percentage of the copper left in the piles of old tailings will be recovered. The quantity of copper awaiting extraction in these heaps of refuse represents a notable proportion of the past production of the mines.

The Arizona Copper Co.'s report for the fiscal year[2] gives the following statements:

During the year the production of Bessemer copper, as finally adjusted, was 37,330,000 pounds. This compared with 38,942,455 pounds for the previous year. The total ores mined from the company's properties during the year amounted to 968,566 dry tons, and the yield, as indicated by the smelter returns on ores treated, was 39.23 pounds of copper per ton of ore—an increase of 3.06 pounds per ton as compared with the previous year. * * *

In January, 1915, the demand for copper again revived, and production was raised to normal, or about 1,800 tons per month, and operations proceeded smoothly until September 11, when a strike was called throughout the entire district for the recognition by the companies of the Western Federation of Miners and a demand for higher wages, and all operations entirely ceased. * * *

During the year No. 6 concentrator treated on the average about 3,000 tons per 24 hours running day, and plans were perfected to increase this capacity to 4,000 tons per day to enable us to draw from the mines a larger proportion of lower-grade ores than has hitherto been treated. This increase of capacity involved the addition to the coarse crushing department of 2 Symons disk crushers, the installation of 12 Cole screens and 24 Wilfley tables in the jigging department, and the substitution of steel linings and balls for flints in our Hardinge mills. These additions and changes were nearly completed at the end of the period when work was stopped by the strike.

[1] Phelps, Dodge & Co. Ann. Rept. for year ending Dec. 31, 1915.
[2] Arizona Copper Co. Ann. Rept. for year ending Sept. 30, 1915.

Experiments with the new oil flotation process, which had been carried on for some time, were so successful that a complete flotation plant, consisting of 85 Callow cells, was ordered and preparations for its installation begun at the time of the shutdown. This plant is expected to be completed before the middle of the current year, and from its operation a very material increase in the efficiency of the concentrator is anticipated.

At Clifton the old sulphide concentrator was being remodeled to treat the ores from the King and Longfellow North Extension mines, which are naturally tributary to the Coronado Railroad, and can be delivered more cheaply at Clifton than at Morenci.

The capacity of this plant will be 500 tons per day, provision being allowed for increasing this should conditions later justify this course.

In this plant the ore will be crushed directly to 48 mesh in Marcy mills and concentrated on tables and by oil flotation.

This plant, which was almost ready to go into commission when the strike occurred last September, was partially destroyed by fire during the shutdown. It is now expected to be operating by April next.

The company's new smelting and power plants gave excellent results during the year.

Operations were continued at the Shannon property in February and cover a period of about seven months, the property being closed down during part of September and all the remaining part of the year, due to labor troubles. During the operating period there were produced at the smelter from the Shannon and other custom ores 6,017,642 pounds of copper, 690.417 ounces of gold, and 35,449.63 ounces of silver. Experiments were made with leaching the mill tailing, and good results were attained. A 150-ton leaching plant is under construction.

San Francisco River district.—Placer operations on the river resulted in the output of a small quantity of gold bullion reported from six sources.

MARICOPA COUNTY.

Twenty-two producers reported the output of 31,123 tons of ore in 1915, which was 8,317 tons less than was reported by 12 producers in 1914. The total average value per ton decreased from $14.39 in 1914 to $9.63 in 1915, and the gold and silver value of this ore from $13.89 to $9.09. The milling ores aggregated 30,375 tons and produced gold and silver bullion and lead concentrates containing a small quantity of copper with good percentages in gold and a little silver. Only 150 tons of ore of smelting grade were shipped from the county. The total value of all of the ore milled and shipped amounted to $299,866, a decrease of $268,329 from 1914. The reports of three placer operators show the recovery of $998 in gold and 6 ounces of silver, against an output of $1,560 in gold and 7 ounces of silver in 1914.

Agua Fria district.—There were mined and treated by cyanidation about 140 tons of ore during 1915, which yielded a small quantity of gold bullion, all of which came from the Relief property.

Cave Creek district.—The output of three deep mines and one placer aggregated $2,780. Most of this value was for the copper and gold ores shipped, and came principally from the Hackensack and Go John properties. The latter property is equipped with a five-stamp mill and concentrator.

Santo Domingo district.—The production of the district consisted of $950 in gold and silver bullion, the output of small placer operations. In 1914 the output amounted to $1,457 in gold and 6 ounces of silver.

Sunset district.—The district is reached from Aguila, on a branch of the Santa Fe route. The producers were the Black Bird, Copper King, and Silver King properties.

Vulture district.—Ore was mined and milled from the Vulture mine, which produced gold and silver bullion and concentrates, the latter carrying some lead and copper. The mine and mill were operated the entire year. A small lot of copper ore was shipped from the Green Mountain property.

White Picacho district.—Small shipments of ore, some containing copper and lead, were made from the district in 1915.

MOHAVE COUNTY.

Mine production in Mohave County, Ariz., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.	*Value.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	43	204,004	$1,891,214	170,845	760,678	3,718,057	9,553,050	$2,719,070
1915	35	227,435	1,626,437	287,214	998,671	6,459,557	17,382,849	4,405,894
Increase or decrease, 1915		+23,431	−264,777	+116,369	+237,993	+2,741,500	+7,829,799	+1,686,824

The total average value per ton of this ore increased from $13.33 in 1914 to $19.37 in 1915, and the gold and silver value decreased from $9.73 to $7.79. The total gold decreased from $1,891,214 in 1914 to $1,626,437 in 1915. The value of the silver increased from $94,477 in 1914 to $145,618 in 1915; that of copper, from $101,170 to $174,767; that of lead, from $145,004 to $303,599; and that of zinc, from $487,205 to $2,155,473. Most of the ore produced in the county is of milling grade and yields bullion and concentrates. There were 136,295 tons of ore treated by amalgamation or cyanidation which produced $1,509,136 in gold and 37,567 ounces of silver, with a total value of $1,528,182, or an average value per ton of $11.21. The concentrating ores aggregating 69,207 tons produced 34,188 tons of concentrates, against 35,188 tons of ore and 18,473 tons of concentrates in 1914. The concentrates contained $99,735 in gold, 228,995 ounces of silver, 45,649 pounds of copper, 6,414,074 pounds of lead, and 16,247,249 pounds of zinc, having a total value of $2,539,945, or an average value per ton of $74.29. Crude ore shipped to smelters amounted to 7,294 tons, against 3,106 tons in 1914. In 1915 shipping ore contained $17,312 in gold, 20,644 ounces of silver, 953,022 pounds of copper, 45,483 pounds of lead, and 1,135,600 pounds of zinc, having a total value of $337,509, or an average value per ton of $46.27.

Aubrey district.—The Doyle property, equipped with a small mill and 2-ton cyanide plant, was operated on a small scale sufficient to keep up assessment work on the property.

Bentley district.—Three producers shipped 1,542 tons of ore having a total value of $132,335, or an average value per ton of $85.82 for the gold, silver, and copper content. The principal producers were the Grand Gulch and Savanic. Included in the total was the output of the Copper Mountain property.

Cedar Valley district.—A very small quantity of gold and silver ore was shipped from the district in 1915.

Chemehuevis district.—The Yellow Jacket & Elsie V. property, formerly the Black Eyed Susan & Comet claim, situated on the western slope of the Chemehuevis Mountains, is equipped with a small amalgamation mill. This was operated a short time testing the ore. The Dutch Flat property, equipped with a 1-stamp amalgamation mill, was in operation testing gold-silver ore.

Cottonwood district.—Copper ore was shipped from the Copper Giant property to the United Verde smelter at Clarkdale, Ariz. The ore is sulphide and the oxidized zone appears to be only 250 feet deep. The property was in operation from the 1st of June to the end of the year.

Gold Basin district.—Cyanide precipitates were produced at the Cyclopic 20-ton cyanide mill, which was operated intermittently during the year.

Greenwood district.—A few tons of ore were mined from the Bland property, producing gold and silver bullion.

Hackberry district.—The 30-ton amalgamation and cyanide plant of the Lucknow and Music Mountain properties was operated in 1915. This mill is equipped with a crusher, a Chile mill, amalgamating plates, concentrating tables, and cyanide tanks. The mine is opened by a 400-foot vertical shaft.

Maynard district.—The Gold Butte, Foot Hill, Louise H., Gold Leader, Fay Bonanza, and Red Hill groups, all adjoining, formerly the property of the Arizona Consolidated Gold Mines Co., were under development by the Arizona Eastern Mining Co. The property has a 5-ton Nissen mill, and amalgamation and cyanidation will be used. The property is opened by an incline shaft 200 feet deep.

San Francisco district.—A mild boom was in progress during 1915. Following sensational discoveries of gold ore in the Tom Reed and United Eastern properties many mining claims changed hands and new companies were organized. There were 132,579 tons of ore mined, from which bullion containing gold and silver was recovered, chiefly by the cyanide process, having a total value of $1,499,033. There were 11 producers, the principal ones being the Gold Road and the Tom Reed. Some gold ore was also mined from the United Eastern property and treated in the Gold Road mill. The Frisco, Banner, Ruth, and Rattan were also producers. Construction work was started on the United Eastern mill, which will have a daily ore capacity of 200 tons. Crushers are to be used instead of stamps, the ore going from the crushers to tube mills, then to the cyanide mill.

Mine conditions at the Tom Reed were reported not so favorable as in former years. According to the company's[1] report for its fiscal year, the gross recovery of gold was $661,870.68, as compared with $1,002,406.60 in 1914, or a yearly average of $739,690.21 for a period of seven years. The total production from the beginning of operations to April 1, 1916, was valued at $5,833,702.17. The dividends paid during the fiscal year amounted to $163,719.90. The ore milled amounted to 29,916 tons, averaging in value $22.12 per ton in gold and silver and representing an average extraction of 98.6 per cent, as against 46,995 tons in 1914, averaging $21.33. About half the ore

[1] Tom Reed Gold Mines Co. Eighth Ann. Rept., for year ending Apr. 1, 1916.

treated came from the stope on the ninth level. From the annual report of the company the following is taken:

At the beginning of the year 1915 the drift on the 1,075-foot level had just been completed. Widths and values in this drift compared favorably with those on the ninth level and also the general average of stopes above. This level (125 feet in height), with top and bottom drifts, both showing good widths and values, gave promise of a normal or average production calculated upon the usual basis of cubical contents.

As stoping progressed upward from the tenth level, however, it was found that the ore body narrowed rapidly, and that about 30 feet above drift the walls of the vein nearly came together. Gradually this "fold" in the vein has widened out as stoping progressed, but its occurrence cut largely into the estimated year's tonnage. It also made mining more difficult and costly; also a marked lowering of values followed the diminished width. In fact, the stope above the tenth level has at no place been as high grade as shown either on the ninth or tenth level drifts, a considerable admixture of waste being present, which has cut the value of this stope down materially. * * *

The total production thus far, approximately $6,000,000, has been gained from two claims, viz, the Tom Reed and the Ben Harrison. The area of these two claims is but 36 acres, while the total acreage owned by this company is 432 acres. * * *

The Gold Road mines[1] produced 96,272 tons of ore in 1915. During the first 11 months the production was at the rate of 8,000 tons of ore per month. The mining cost was $3.15 and the milling cost $2.13 per ton. The recovery of gold was $6.77 per ton. Stoping operations had been carried down to the 500-foot level prior to 1912 by the old company, and since then stoping operations have been extended on the strike of the vein and also in depth to the 900-foot level. The assay value of the ore diminishes with depth as far as heretofore explored, and only a small percentage of the ore found on the 800-foot level is of pay grade, though the vein continues strong and permanent. Sinking is going on from the 900-foot level to reach a depth of 1,500 feet to test the ore at the lower horizon.

Wallapai district.—Altogether 85,635 tons of ore, mined by 10 producers, contained $107,550 in gold, 243,819 ounces of silver, 46,171 pounds of copper, 6,452,406 pounds of lead, and 17,382,849 pounds of zinc, valued in all at $2,697,982, or an average value per ton of $31.51. Of the total ore mined in the district, 69,207 tons were concentrated and yielded 34,161 tons of concentrates, principally zinc, carrying some silver and a little copper. There were also 1,790 tons of ore shipped directly to the smelter containing gold, silver, copper, lead, and zinc. Some tailings were reconcentrated. The principal producers were the Union Basin, Tennessee, Shooting Star, Rainbow, and Roger Boy properties. The Union Basin or Golconda zinc mine, after proving the continuity of the ore to the 900-foot level, was building a 200-ton flotation plant, which should be running early in 1916.

The Tennessee mine, situated at Chloride, according to a recent report,[2] has been operated since 1909 under bond and lease running 10 years. The ore produced contains gold, silver, lead, and zinc in varying proportions and occurs in a fissure vein striking north and south. The ore shoot averages about 300 feet in length and 6 feet in width and has been followed down to the 1,170-foot level. The ore

[1] United States Smelting, Refining & Mining Co. Tenth Ann. Rept. for year ending Dec. 31, 1915, with statement to the New York Stock Exchange appended, dated Feb. 15, 1916.

[2] Statement to New York Stock Exchange, dated Feb. 15, 1916, by the United States Smelting, Refining & Mining Co.

is extracted through a shaft, which has reached a depth of 1,300 feet and is being continued to the 1,400-foot level. The mine is equipped with hoists run by steam power. The ore output, about 100 tons a day, is sent to the company's plant at Needles, Cal., where two products are obtained. A lead concentrate carrying gold and silver is shipped to the United States smelter at Midvale, Utah, and a zinc concentrate is shipped to the eastern plants of the American Metals Co. The present output is about 800 tons of lead concentrate and 1,200 tons of zinc concentrate per month. The Champion, Banner, and Stockton Hill groups of mines are controlled by the same interests. The Champion mines, in the same district, are situated 12 miles north of Kingman and, with the Banner group, are worked by lessees. No development work is being done on the Stockton Hill group. The mill at Needles, Cal., was operated throughout 1915 at full capacity. It is a fully equipped concentration plant of a daily capacity of 125 tons and has crushers, jigs, tables, and a flotation plant, the latter for the recovery of zinc from tailings. Nearly all the 47,897 tons of ore treated at the mill in 1915 came from the Tennessee mine and small quantities from other mines.

PIMA COUNTY.

Forty-nine operators produced 35,394 tons of ore in 1915, against 9,657 tons and 28 producers in 1914. The output of these deep mines in 1915 included $4,186 in gold, 55,854 ounces of silver, 3,561,783 pounds of copper, 57,824 pounds of lead, and 252,527 pounds of zinc, valued in all at $689,847, or an average value per ton of $19.49. The placer output was $2,636 in gold and 27 ounces of silver. Nearly all the ore produced was of shipping grade, only 22 tons being treated at a gold and silver mill and yielding a little bullion.

Ajo district.—The total output of the district reported by five producers aggregated 94 tons, principally copper ore, valued at $3,611. The New Cornelia copper plant, according to its company's report[1] will not be ready for operation before July, 1917. A 40-ton experimental plant was completed on January 31, 1915, and immediately put into operation. Approximately 12,222 tons of ore, or the equivalent of 291 leached charges, were treated. The results are said to amply justify the immediate construction of the permanent plant, which, when complete, will put the New Cornelia property on a production basis of 36,000,000 pounds of copper a year. Work on the 43.5 miles of the Tucson, Cornelia & Gila Bend Railroad was begun in August to connect the mines with Gila Bend, on the Southern Pacific main line. Work progressed rapidly, and by December 31 all of the grading had been completed and approximately 35 miles of rails laid. Regular service was begun February 20, 1916.

Arivaca district.—There were five producers shipping small lots of ore aggregating 32 tons, containing gold, silver, copper, and lead, having an average value per ton of $33. Lessees operated on the Copperopolis group and made the principal shipments in the district. The placers in the Duzrano, Pisquero, and Yaqui gulches in the Giujas Mountains, 60 miles southwest of Tucson, were operated by the New Venture Placer Mining Co., beginning in November. The Clark agitating sluice was tried, which is somewhat similar in op-

[1] Calumet & Arizona Mining Co. Ann. Rept. for year ending Dec. 31, 1915.

eration to the Dorr classifier. Although not a dry machine, it works with a small volume of water. The work was all experimental preparatory to operation on a larger scale and a thorough examination of the deposits.

Baboquivari district.—Copper ore carrying gold and silver was shipped from the Papago Chief, La France, and Beach & Little George properties in 1915.

Empire district.—Four deep mines produced 100 tons of ore carrying gold, silver, copper, and lead, having an average value per ton of $21.44. The principal producers were the Andrade and Total Wreck properties.

Greaterville district.—The Billy Sunday group yielded a small tonnage of gold and silver ore containing a little copper. There was also a small production of gold bullion from the placers in the district.

Gunsight district.—The Victoria property yielded copper-lead ore of shipping grade, containing gold and silver.

Helvetia district.—Six producers shipped 2,506 tons of ore during 1915, which contained $248 in gold, 3,300 ounces of silver, 349,945 pounds of copper, valued in all at $63,161, or an average value per ton of $25.20. The principal producers were the Naragansett, Helvetia, Cuprite, Sweet Bye and Bye, and Bulldozer properties.

Indian Oasis district.—A small quantity of gold bullion, said to have been produced in the district, came principally from placers operated by Mexicans and Indians.

Old Baldy district.—A small quantity of copper ore carrying gold and silver was shipped from the Old Hickory copper property.

Pima district.—Twenty-one deep mines produced 32,150 tons of ore, containing $2,283 in gold, 43,726 ounces of silver, 3,164,358 pounds of copper, 28,013 pounds of lead, and 47,762 pounds of zinc, valued in all at $585,454, or an average value per ton of $18.21. This ore was of shipping grade, the largest part of it being shipped from the Bush & Baxter property. Shipments were also made from the Mineral Hill, Olivett, Plumed Knight, Red Carbonate, and Vulcan properties.

Quijotoa district.—Only one small shipment of gold ore carrying silver was reported shipped from the district. Considerable development work was performed on the copper properties, which should result in a production in 1916.

Silver Bell district.—Zinc carbonates and sulphides were shipped from the Atlas property to smelters in Kansas.

PINAL COUNTY.

Forty-six operators produced 2,928,639 tons of ore, the principal part of which was the output of one producer. The total output was greater by 466,180 tons than the production of 27 operators in 1914. The total average value per ton increased from $3.32 in 1914 to $4.14 in 1915, and the gold and silver value in this ore from 6 cents to 9 cents per ton. Nearly all of the ore, or 2,910,579 tons, was of concentrating grade and produced 173,740 tons of concentrate, most of which contained copper, there being only a small quantity of lead concentrates, which were recovered from one property. The ores of

smelting grade shipped directly to smelters aggregated 17,057 tons, containing 407.48 ounces of gold, 84,146 ounces of silver, 3,111,453 pounds of copper, 54,615 pounds of lead, and 16,620 pounds of zinc, valued in all at $600,216, or an average value per ton of $35.19. In 1914 the shipments of ore aggregated 9,493 tons, valued at $315,644, or an average value per ton of $33.25. At gold and silver mills 1,003 tons of ore were treated and produced 535.95 ounces of gold and 142 ounces of silver. Placer bullion was recovered amounting to $606 in gold and 3 ounces of silver, against an output valued at $503 in gold and 5 ounces of silver in 1914.

Bunker Hill district.—The Cumberland group, operated by lessees, produced a small quantity of copper-lead ore. Properties located a mile north of the Sombrero Butte Mountain were reported to have shipped some 25 per cent copper ore carrying small silver values.

Casa Grande district.—Six producers mined 2,611 tons of ore, of which the larger part was of milling grade and yielded lead concentrate carrying much silver. There were 913 tons shipped directly to smelters, which carried gold, silver, copper, lead, and zinc. The Vekol property, with its 50-ton concentrating plant was the principal shipper of lead concentrate. The Silver Reef or Nugget property shipped copper ore and lead ore containing gold and silver. The Copperosity was also a producer of oxidized copper ore.

Goldfields district.—The Mammoth group was the principal producer, yielding gold and silver bullion recovered from ore treated in the 20-stamp mill and 50-ton cyanide plant, which were operated three months in 1915.

Mineral Creek or Ray district.—The largest output of the district was made from the Ray mine. Important quantities of ore were also produced from the Arizona Hercules and Ray Arizona properties. The Ray mines[1] issued a printed report containing the following paragraphs:

At the commencement of the year the mine was operated at less than normal capacity, as industrial conditions did not warrant full production. In the latter part of the first quarter the demand for copper improved, and the output was gradually increased for the second quarter. During the third quarter labor disturbances seriously interfered with operations and output, and the fourth quarter was, therefore, the only one in which the mine output was approximately normal, averaging for that period 8,633 tons per day.

The above-mentioned 2,854,314 tons of ore mined consisted of 2,852,577 tons of concentrating ore, averaging 1.673 per cent copper, and 1,737 tons of sorted ore from the No. 3 shaft, which was shipped direct to the smelter. In addition to the ores produced by regular operations 9,203 tons were mined and shipped direct to the smelter from surface deposits. The concentrating ore mined during the year was derived, 4 per cent from development, 6 per cent from active stoping, and 90 per cent from reserve drawing. Mining operations in all ore bodies have now progressed to a state where it is not necessary to have such a large reserve of broken ore as formerly, and this now amounts to about 3,000,000 tons, equivalent to a year's supply for the mill.

The net mining costs for the year show a slight decrease over those for the previous year. The percentage of the ore from broken reserves has shown an increase, but the saving which would have normally been effected by this was offset by the adverse operating conditions prevailing during part of the year and by the higher wage scale which was paid during the last half of it. The average cost of mining for the year was 62.68 cents per ton, as compared with 62.42 cents for 1914. This cost included the fixed and general charges, as well as the cost of operating the coarse crushing plants at the mine and the loading of the crushed ore in the railroad cars for shipment to the mill. The latter

[1] Ray Consolidated Copper Co. Ann. Rept. for year ending Dec. 31, 1915.

costs amount to 3.71 cents per ton, leaving the net cost of mining 58.97 cents per ton, as compared with 59.32 cents in 1914. * * *

The total ore milled for the year was 2,848,969 tons, corresponding to a daily average of 7,805 tons, as compared with 2,427,700 tons for 1914. The total tonnage of ore milled since the beginning of operations and to the end of 1915 was 9,889,360 tons, averaging 1.717 per cent copper. The average grade of the ore milled for 1915 was 1.673 per cent copper, as compared with 1.76 per cent for 1914. The average recovery was 64.11 per cent, corresponding to 21.45 pounds of copper per ton, as compared with 67.88 per cent, or 23.9 pounds of copper per ton for the previous year. The recoveries were affected adversely during the first half of the year by irregularities in operations and even more so during the latter half by interference of construction work in mill improvements at a time when the price of copper was such that it was more profitable to treat a normal tonnage by increasing the load on sections not affected by the construction work, even at some sacrifice in metal recoveries.

The cost of milling increased slightly for the year and was 50.86 cents per ton, as compared with 49.88 cents for the previous year. * * *

The average grade of concentrates for the year was 19.293 per cent, as compared with 19.25 per cent for the year 1914. In addition to the copper contained in concentrates there were produced from ore shipped direct to the smelter 1,425,682 pounds, making the gross production of copper from all sources 62,540,196 pounds. The average cost per pound of net copper produced from milling ores, after making allowances for smelting and refining deductions and crediting dividends from the Ray & Gila Valley Railroad (but no other miscellaneous income), as a reduction of operating costs, was 9.478 cents per pound. The combined cost per pound of net copper produced from milling ore and direct shipping ore for the year was 9.497 cents, as compared with 8.839 cents per pound for the previous year. These costs include all operating and general charges as well as 12½ cents per ton of ore milled, which is applied to the retirement of mine development costs. This latter charge is equal to 0.59 cent per pound of net copper produced from all sources for the year. By crediting all miscellaneous income as a reduction of costs, the per pound cost of net copper produced becomes 9.423 cents, as compared with 8.763 cents for the previous year.

Old Hat district.—Fourteen producers of ore and one of placer bullion reported a total production of $946 in gold, 1,391 ounces of silver, 35,431 pounds of copper, and 1,827 pounds of lead, valued in all at $7,939. The placer bullion contained in this output was small and from one property. Altogether there were 126 tons of ore produced, which had an average value per ton of $58.30. The principal producers were the Cuba, Superior, Farris group, Tip Top, Golden Eagle, and Copper Princess properties.

Pioneer district.—The Magma mine with its 150-ton concentrator was at work the entire year and a large quantity of copper ore and concentrate carrying considerable gold and silver was shipped to the smelting plant at Hayden. There was also some copper ore shipped from two other properties. In 1915 the railroad branch 28 miles long was completed from Webster, on the Arizona Eastern Railroad, 9 miles northwest of Florence, Ariz., to the mine and mill of the Magma Copper Co., at Superior. The mill of this company is connected with the mine by a 2,600-foot Bleichert aerial tramway, which operates by gravity except for a 10-horsepower starting motor. The equipment of the mill consists of jaw crushers, disk crushers, a ball mill, and a pebble mill. The tailings from the finishing tables are treated by the Callow flotation process. All concentrate passes through classifiers and the overflow of this goes to a filter press. The discharge of the classifier and press is a shipping product. According to the annual printed report of the company[1] it mined and treated 59,219 tons of copper ore, of which 3.756 tons were sorted ore shipped

[1] Magma Copper Co. Ann. Rept. for year ending Dec. 31, 1915.

directly to the smelter and the remainder was milled, producing 15,039 tons of copper concentrate. The sorted ore averaged 18.44 per cent of copper, and 20.09 ounces of silver and $1.58 in gold per ton; the copper concentrate, averaged 16.67 per cent of copper, and 19.05 ounces of silver and $2.18 in gold per ton. The recovery was 86.76 per cent of the copper content of the mill feed and 89.32 per cent of the copper content of the mine-run ore treated by hand sorting and milling. The company estimates its copper ore reserves at 90,000 tons, assaying 6.65 per cent of copper, and 6.75 ounces of silver, and 0.029 ounce of gold a ton. The probable lead-zinc ore in the mine is estimated at 10,000 tons, assaying 14 per cent of zinc, 4 per cent of lead, and 10 ounces of silver per ton. From the company's report the following extracts are taken:

> The known ore bodies of the mine occur in a strong fault fissure filled with porphyry and cutting diabase, quartzite, and limestone. * * *
>
> A new 3-compartment working shaft has been completed and equipped from the main 200-foot tunnel level to 30 feet below the 1,200-foot level, and the 900-foot, 1,100-foot, and 1,200-foot levels have been partially prospected and developed. This work below the 800-foot level, which is in the diabase, has shown commercial ore on all of these levels, so that there has now been proven continuous commercial ore from the 500-foot level to the 1,200-foot level. The extent of the mineralization on the lower levels and the grade of the ore encountered on the 1,200-foot level indicate the probability of commercial ore continuing in depth below the 1,200-foot level. It is also quite probable that in drifting other ore shoots will be found in the Magma fissure, which has continued strong in depth and laterally.
>
> In addition to the copper ore bodies, development work on the lower levels has exposed a very good grade of zinc, lead, and silver ore. This ore occurs in distinct shoots, separate from the copper ore and, undoubtedly, will be an asset to the company.

Riverside district.—There were shipped from the district 213 tons of copper ore carrying gold and silver, and one property mined concentrating ore, yielding copper concentrates containing a small quantity of silver. The principal producer was the Kalvin Sultana property, which is equipped with a 200-ton wet concentrating plant. In addition to the concentrates, there was also some oxidized copper ore which was shipped directly to the smelter.

SANTA CRUZ COUNTY.

There were 27 producers reporting 14,360 tons of ore in 1915, which is 1,537 tons more than was reported by 34 producers in 1914. The total value of this ore, containing gold, silver, copper, lead, and zinc, was $292,514 in 1915, against $409,774 in 1914. In 1915 the ore sold and treated contained $6,096 in gold, 68,728 ounces of silver, 810,774 pounds of copper, 1,192,492 pounds of lead, and 432,582 pounds of zinc, valued in all at $292,514, or an average value per ton of $20.37. Ore of shipping grade amounted to 4,457 tons and contained most of the copper and some of the lead. The classification of the ores produced shows that most of it was lead ore, aggregating 7,136 tons; copper ore, 3,860 tons; zinc ore, 2,800 tons; and copper-lead ore, 179 tons. The placer production reported by 3 operators amounted to $506 in gold and 6 ounces of silver.

Harshaw district.—Silver ore containing some lead and copper was shipped from the World's Fair property by lessees. The Eldorado claim was productive of copper oxidized ore containing a little silver.

Nogales district.—Several small shipments of ore aggregating 206 tons were reported to have been mined in the district and to contain gold, silver, copper, and lead valued at $11,258, or an average value per ton of $54.65.

Oro Blanco district.—Eight producers reported a production of 169 tons of ore containing gold, silver, copper, and a little lead from one property, valued in all at $6,211, or an average value per ton of $36.75. The output contained a small output of bullion recovered from ore treated in a milling plant in the district. The producers were the Old Glory, Ophir, Black Peak, and Master properties.

Patagonia district.—Six deep-mine producers shipped 13,400 tons of ore, containing $1,703 in gold, 27,588 ounces of silver, 716,321 pounds of copper, 1,092,707 pounds of lead, and 432,582 pounds of zinc, valued in all at $246,043, or an average value per ton of $18.36. About two-thirds of the ore, or 7,373 tons, was of milling grade and produced concentrates containing lead, zinc, gold, and silver. The remainder, 3,527 tons, was shipped directly to the smelters. The principal producers were the Duquesne and Flux properties.

Tyndall district.—Three producers shipped 179 tons of ore containing gold, silver, copper, and lead, with an average value per ton of $43.07. The principal production came from the Royal Blue, Three Stars, and Florida claims.

Wrightson district.—The Blue Lead property produced a few tons of lead ore, containing some silver, copper, and a little gold. There was also a shipment of copper ore containing gold and silver from the American Boy property.

YAVAPAI COUNTY.

Mine production in Yavapai County, Ariz., in 1914 and 1915.

Year	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.	*Value.*	*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	100	459,982	$557,064	786,917	34,057,952	169,959	.....	$5,528,565
1915	107	614,843	791,884	1,343,363	59,229,103	161,750	48,580	11,851,688
Increase or decrease, 1915		+154,861	+234,820	+556,446	+25,171,151	−8,209	+48,580	+6,323,123

[a] Includes placer production.

Reports received from 89 deep mines and 18 placers gave a total metal output in 1915 whose value was $6,323,123 greater than the value of the output in 1914 reported by 100 operators of deep mines and placers. The total average value per ton of the ore increased from $11.99 in 1914 to $19.25 in 1915, and the gold and silver value in this ore from $2.13 to $2.37. Of the total value of the metals reported, $791,884 was for gold, $681,085 for silver, $10,365,093 for copper, $7,602 for lead, and $6,024 for zinc. When the output is compared with that of 1914, all of the metals except lead show substantial increase. Ores of smelting grade shipped to smelters in the county and State, and some of it to outside plants, aggregated 527,841 tons, the larger part of which was copper ore (526,890 tons), of which the larger part was sulphide ore (516,346 tons), and the remainder cop-

per oxidized ore (10,544 tons). The total value of the smelting ores was $10,910,957, or an average value per ton of $20.67. There were produced 12,143 tons of dry or siliceous ore, the larger part of which was treated at gold and silver mills. Concentrates amounting to 12,467 tons, derived from 75,919 tons of ore, were also smelted, and contained $48,392 in gold, 67,191 ounces of silver, 3,844,854 pounds of copper, 48,777 pounds of lead, and 48,580 pounds of zinc, valued in all at $763,625, or an average value per ton of $61.25. The placer output amounted to $13,910 in gold and 133 ounces of silver, as against a production of $12,190 in gold and 87 ounces of silver in 1914.

Agua Fria district.—The Gold Dot claim in Yaba Gulch yielded a few hundred pounds of copper ore carrying silver.

Big Bug district.—Eighteen deep mines and 3 placers reported an output of ore and bullion valued at $847,616. Altogether there were 83,598 tons of ore mined, of which the larger part, or 71,039 tons, was concentrated and yielded 10,866 tons of concentrate containing 1,638.78 ounces of gold, 53,321 ounces of silver, 3,553,826 pounds of copper, and 22,295 pounds of lead. The ore of shipping grade aggregated 11,698 tons, containing 509.08 ounces of gold, 27,020 ounces of silver, 731,842 pounds of copper, and 55,875 pounds of lead. The placer output amounted to $4,119 in gold and 54 ounces of silver, against a production reported in 1914 of 2,032 ounces of gold and 11 ounces of silver. The larger part of the output of crude ore and concentrates was from the Blue Bell mine and was treated at the Consolidated Arizona smelter, at Humboldt. This ore carries copper, gold, and silver. The mine is opened by an incline shaft 1,000 feet deep, which, in 1915, was sunk an additional 150 feet. The introduction of flotation—together with other changes in milling methods—at the copper concentrator of the Consolidated Arizona smelter at Humboldt is reported [1] to have increased the recovery of copper by more than 20 per cent over the best saving previously made with jigs, tables, and vanners. Milling ore from the company's Blue Bell mine and its De Soto property in the Peck district is a siliceous sulphide containing pyrite and chalcopyrite in a gangue of quartz and schist. The average composition of the ore treated and its products are as follows:

Ore and mill products of Consolidated Arizona Smelting Co., with average assays per ton.

Material.	Gold.	Silver.	Copper.	Insoluble.	Iron.	Lime.	Magnesia.	Alumina.	Sulphur.
	Ounces.	*Ounces.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*	*Per ct.*
Milling ore	0.03	1.3	3.0	65.0	10.9	1.0	1.2	4.7	13.0
Table concentrate	.09	2.3	7.0	10.0	35.0	.....	.....	.....	.....
Table tailing, flotation feed	.025	1.0	2.1	.....	5.8	.....	.....	.....	.....
Flotation concentrate	.10	5.0	14.0	24.0	22.4	.....	.....	.....	.....
General mill concentrate	.09	3.04	9.52	16.5	30.0	.....	.....	.....	.....
Mill tailing, flotation tailing	.01	.4	0.3	.....	3.0	.....	.....	.....	.....

During the month of September, 1915, the total quantity of ore milled was 7,173 tons. The average grade of mine ore contained 2.7 per cent of copper and the average of all material, including old tail-

[1] Flotation at the Consolidated Arizona Smelting Co., Humboldt, Ariz.: Met. and Chem. Eng., vol. 13, pp. 897–901, Dec. 1, 1915.

ing, 2.65 per cent. The percentage of recovery of valuable metals was 90.9 per cent of the copper, 68 per cent of the gold, and 72 per cent of the silver. The gross quantity of copper in concentrates was 345,000 pounds, of which 240,000 pounds, or nearly 70 per cent, was recovered by flotation. The usual recovery by flotation will average about 75 per cent of the total. The ratio of concentration in the entire mill was about 4 to 1 and in the flotation between 7 and 8 to 1.

Considerable copper oxidized ore was produced also from the Henrietta mines, and smaller quantities were produced from the Wizard, Great Belcher, and Mountain Chief properties. Ores carrying lead were produced from the Arizona mines, the Poland, and the Silver Belt properties. The Jones group produced gold and silver bullion with some concentrate. The Little Jessie mine was also a producer of a small amount of gold and silver bullion.

Black Canyon district.—A small output of gold-silver ore yielded some bullion from the Katy property.

Black Rock district.—Three producers reported output of gold-silver-copper ore having an average value per ton of $39.39. The principal production was from the Golden State property, and small shipments of ore came from the Big Blue and Royal Consolidated claims.

Castle Creek district.—Gold-silver ore carrying some copper was reported to have been shipped from the Dover property in 1915.

Cherry Creek district.—Ore from five deep mines yielded gold, silver, copper, and lead valued at $958, or an average value per ton of $11.14. Most of the ore was treated at small milling plants in the district and yielded bullion, and some ore was shipped directly to the smelter. Ore was mined from the St. Patrick, Garford, and Esmeralda properties.

Copper Basin district.—The principal operations were carried on by the Commercial Mining Co., which shipped sulphide copper ore from its Senator group and oxidized copper ore from its Copper Basin property to the smelters at Douglas and Hayden.

Eureka district.—The ore mined from the Nieman & Cyglance group and the Bell claim was treated in milling plants in the district and produced gold and silver bullion.

Hassayampa district.—Nineteen deep mines produced 2,209 tons of ore, containing $20,366 in gold, 26,292 ounces of silver, 100,314 pounds of copper, and 49,827 pounds of lead, valued in all at $53,593, or an average value per ton of $24.26. The larger part of this ore was of milling grade, producing gold and silver bullion, from the Climax. In addition, some concentrate containing lead was produced from the Emporia and the Cash or Y. P. mines, and copper concentrates containing gold and silver from the Dunkirk property. All four of these mines are equipped with milling plants. Copper ore containing principally gold and a little silver was produced from the Empire mine and some from the Lookout, Little Johnnie, Cottonwood, and Vera properties.

Humbug district.—The Brown mine yielded a few tons of ore shipped to a lead smelter.

Peck district.—The De Soto property was the principal producer, shipping copper sulphide and oxidized ores to the company's smelter at Humboldt. Some ore was also produced from the Peck and Nora B. properties.

Silver Mountain district.—The Monte Carlo claim produced some ore, which was treated in a 1-ton arrastre and yielded gold and silver bullion.

Tiger district.—Old tailings from the dump of the Crown King mill were re-treated and yielded three classes of concentrate—copper, gold-silver, and zinc. Some ore from the Giltedge property was also milled and produced gold and silver bullion. The Tiger Gold mine and mill were operated during the year and yielded gold and silver bullion and a small quantity of concentrate. The oil-flotation process was placed in use at the Crown King mill for treating the ores and tailings in the region, and the process has also been installed in the 20-stamp mill on the Tiger Gold property.

Turkey Creek district.—The reports of 5 operators gave a production of 64 tons of ore containing gold, silver, and a little lead, valued at $1,527, or an average value per ton of $23.86. The largest output in value was from the Holmes mine. Other producers were the Brooks and Ames groups.

Verde district.—There were 5 producing properties in the district in 1915, the principal one being the United Verde, which shipped copper ore to its new smelter at Clarkdale, blown in on May 26. The United Verde mine produces three classes of ore which make a mixture that is largely self-fluxing, and in addition thereto a high-grade limestone is obtained from a local deposit. Typical analyses of the three classes of ore are given in the following table:[1]

Analyses of furnace charge used at United Verde Copper Co.'s smelter, 1915.

Material.	Copper.	Silica.	Iron.	Sulphur.	Lime.
Iron	5.5	11.5	33.0	37.0	.....
Siliceous ore	5.8	22.0	26.0	25.0	.....
Oxidized ore	.8	70.0	17.0	1.2	.....
Convertor chips	9.5	16.0	47.0	6.5	.....
Limestone	.....	6.0	.....	.....	50.0

The new smelting plant of the United Verde Copper Co. erected in 1914–15 is at Clarkdale, Ariz., in the valley of Verde River, about 5 miles distant from and 2,000 feet below the town of Jerome, where the old plant was situated. The Clarkdale plant is equipped for both reverberatory and blast furnace smelting by the most approved modern methods, and, although erected primarily to treat the company's own ores, it is available for smelting such custom ores as are offered from the region. Blast-furnace smelting is the most important operation, with regard to tonnage treated, but the reverberatory furnaces are a valuable adjunct for smelting fine ore and flue dust. The most important ore is a heavy sulphide, well suited to blast-furnace treatment; the second type is a more siliceous sulphide; and the third is a highly siliceous ore. At the smelter these ores are designated as iron, silica, and oxide, respectively. The last is used not only as a constituent of the blast-furnace charge, but portions of it are so highly siliceous as to be useful for converter flux and reverberatory fettling. An important characteristic of the United Verde ore is its remarkable freedom from arsenic and antimony.

[1] Met. and Chem. Eng., Sept. 1, 1916, p. 251.

Notable among the new producers was the output of the United Verde Extension, which was operated the full year. The mine is equipped with an aerial tramway from the mine to the railway, a distance of about 1 mile. It is opened by two shafts, 800 and 1,200 feet deep, connection between them being made on the 800-foot level. The Cleopatra shipped considerable copper, and the Copper Chief Mine and its 120-ton cyanide plant began operations on September 1 and produced gold and silver bullion. The ore is oxidized and carries a little lead and copper. Consolidation of property in the district in 1915 leaves practically the whole region to the operation of two companies. The Hull and Cleopatra mines are said to have been purchased by the United Verde Copper Co., and the United Verde Extension Mining Co. owns very nearly all of the surrounding claims not included in this deal.

Walker district.—The output of 3 deep mines and 6 placers contained $15,519 in gold, 4,635 ounces of silver, 16,440 pounds of copper, and 7,378 pounds of lead, valued in all at $21,093. There were 899 tons of ore mined in the district, having an average value per ton of $18.38. The placer bullion contained $4,545 in gold and 42 ounces of silver. The Eureka and Fortune ore was treated at the Poland mill and yielded bullion and copper and lead concentrate. A small quantity of gold and silver ore was shipped from the Black Diamond property. The Wichita Placer Mining Co. has purchased one of the Lynx Creek properties and expects to have a successful hydraulic plant in operation in 1916. It has four hydraulic giants, the first to be installed in the Lynx Creek field. A supply of water said to be sufficient for continuous placer-mining operations has been conserved in the company's dam; two sets of sluice boxes—each 40 feet long in 4 sections—are in place; and the big pumps have been set up and are in working order.

Walnut Grove district.—Several small shipments of ore containing gold, silver, and copper were made from the district and a little bullion was recovered from some ore by amalgamation. The total output, including the bullion from one surface mine, amounted to $1,997. The ore aggregated 76 tons and averaged per ton $24.21.

Weaver district.—Three deep mines and 5 placers produced $7,168 in gold and silver. The ore aggregated 151 tons, producing gold bullion and a little concentrate, and averaged $15.95 per ton. The Monica mine was operated and the ore treated in the 50-ton amalgamation and cyanide plant on the property. Most of the placer gold was produced on Rich Hill.

White Picacho district.—Four operators produced 45 tons of ore, yielding gold, silver, copper, and lead valued at $1,243, or an average value per ton of $27.62. The Fairview, Gold Rope, Producer, and Golden Rule were the principal claims operated.

YUMA COUNTY.

Forty-six producing deep mines in Yuma County in 1915 reported 29,259 tons of ore, 1,482 tons more than was reported by 26 producers in 1914. The total average value per ton of this ore increased from $2.14 in 1914 to $12.95 in 1915, and the gold and silver value decreased from $1.30 in 1914 to 97 cents in 1915. The total value of the gold, silver, copper, and lead produced in the

county was $392,894, as against an output of $64,890 in 1914. There was an improvement in the production of placer gold from surface mines, which in 1915 yielded $14,005 in gold and 104 ounces of silver, against a recovery of $5,517 in gold and 45 ounces of silver from 22 placers in 1914. The larger part of the placer gold is from the Quartzsite region. Ore of shipping grade aggregated 28,517 tons, containing 788.82 ounces of gold, 5,812 ounces of silver, 1,961,504 pounds of copper, 96,205 pounds of lead. At gold and silver mills there were 257 tons of ore and 125 tons of old tailings treated, which produced 361.70 ounces of gold and 1,564 ounces of silver.

Castle Dome district.—The output of 9 deep mines and 2 surface properties amounted to $16,169. The ore produced carried gold, silver, copper, and lead and amounted to 646 tons, having an average value per ton of $23.32. The placer production amounted to $1,101 in gold and 4 ounces of silver. The Big Eye property was an important producer, yielding gold and silver bullion from the treatment of ore by amalgamation and cyanidation. The property was operated only a few months. The Castle Dome Mining Co. operated its property and produced a few tons of lead concentrate.

Cienega district.—There were several shipments of ore from the Mammoth Zeolite property. This ore assayed from 5 to 9 per cent copper. The Billy Mack property was also a producer.

Ellsworth district.—There were 14 deep mines producing 448 tons of ore containing $4,920 in gold, 227 ounces of silver, and 45,202 pounds of copper, valued in all at $12,945, or an average value per ton of $28.90. The producers were the Dick Bullard mines, Tough Nut, Victor & Bell Crown, Dream, Dandy group, and Davis & Fleming group. The Yuma Warrior Mining Co. began the development of the Harqua Hala, Bonanza, and Golden Eagle groups about three years ago and was preparing the 40-stamp mill for operation at the close of 1915. The property was worked in the early days to a depth of 400 feet; levels were driven at intervals of 50 feet, some of them for a considerable length; but the deeper ore is still undisturbed save for the new work. The ore carries gold and also some copper.

Kofa district.—There were a few tons of ore milled in an arrastre, and some ore was shipped directly to the smelter. This, in addition to a small ouput of bullion from surface mines, aggregated $7,433. The Quartette property was the principal producer. The geology of the district is described in a recent report[1] by the Survey.

Laguna district.—There were several small productions of placer bullion in the region, but no reports were received from producers. Most of the gold produced was bought by storekeepers.

Palomas district.—One storekeeper reported the production of a small quantity of placer bullion bought during 1915.

Planet district.—The district was partly revived by the operations of the Swansea mines. Some sulphide copper ore, which is said to have averaged about 3 per cent, was shipped to Humboldt. The New Planet property was also operated and produced copper sulphides which it is said averaged about 9 per cent copper. Most of this ore

[1] Jones, E. L., jr., A reconnaissance in the Kofa Mountains, Ariz.: U. S. Geol. Survey Bull. 620, pp. 151–164, 1915.

was sold to the smelter at Hayden. The Planet mine is opened by a vertical shaft 668 feet deep and has an incline shaft 738 feet deep.

Plomosa district.—Ten deep mines produced 219 tons of ore, containing $5,350 in gold, 585 ounces of silver, 24,803 pounds of copper, and 1,854 pounds of lead, valued in all at $10,075, or an average value per ton of $46. The bullion reported from placer operations amounted to $3,600 in gold and 15 ounces of silver. Among the deep mines operating were the Bullion, Dutchman, Excelsior, Golden Horn, and the Old Maid. The principal part of the placer gold came from the Chappo group, the ground of which was worked in a crude way with small fans and a blowing machine. A description of the properties and a brief history of the district are given in a recent report [1] issued by the Survey.

[1] Jones, E. L., jr., Gold deposits near Quartzsite, Ariz.: U. S. Geol. Survey Bull. 620, pp. 43–57, 1915.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN IDAHO.

(MINES REPORT.)

By C. N. Gerry.

PRODUCTION.

GENERAL STATEMENT.

The value of the mine production of gold, silver, copper, lead, and zinc in Idaho in 1915 was $33,328,930, an increase of 35 per cent over the value in 1914. Both silver and lead decreased, gold and copper increased slightly, and zinc increased notably. The value of all metals was greater than in any previous year. This resulted not only from the record production of zinc but from the general increase in prices of metals.

The production of the State from the discovery of placer gold to the end of 1915 is given in the table below. The total[1] to 1914, inclusive, has been previously given by periods. It shows that the State has been an important producer of the five metals, which have a total value of more than $500,000,000. Of this total, lead represents $220,285,083, or nearly 43 per cent; silver, $134,773,693, or more than 26 per cent; gold, $128,990,350, or more than 25 per cent; and copper, $15,338,846, and zinc (spelter) $14,562,297, or nearly 3 per cent each. The value of the output of zinc in 1915 exceeded the total value of zinc for all previous years.

Mine production of metals in Idaho in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	384	2,235,349	$1,152,315	12,479,516	6,445,187	348,526,069	42,012,435	$24,645,848
1915	412	2,408,846	1,179,731	11,769,128	6,978,713	345,999,466	70,153,234	33,328,930
Increase or decrease, 1915	.....	+173,497	+27,416	−710,388	+533,526	−2,526,603	+28,140,799	+8,683,082
Total, 1863–1915	.....	.....	128,990,350	200,375,744	100,059,074	5,002,706,950	174,859,285	513,950,269

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 598, 1915.

The tables giving separation according to source of metals shows a distinct increase in recoveries from lead-zinc ore and a decrease in the placer output of gold.

Ore and metals produced in Idaho in 1915.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	186	.....	28,294.05	5,935	.....	.....	.....
Dry or siliceous ore	126	52,302	21,935.45	74,481	4,661	12,659	.....
Copper ore	25	74,901	3,997.33	171,931	5,510,427	843	.....
Lead ore	64	1,656,688	2,306.28	9,791,944	1,393,961	294,551,932	52,299
Zinc ore	11	111,428	8.27	138,463	.....	3,781,463	22,436,610
Copper-lead ore	1	2	.05	27	464	559	.....
Lead-zinc ore	11	513,525	528.06	1,586,347	69,200	47,652,010	47,664,325
	.....	2,408,846	57,069.49	11,769,128	6,978,713	345,999,466	70,153,234

ORE.

The quantity of ore sold or treated in Idaho in 1915 increased 173,497 tons, or nearly 8 per cent. Lead ore and lead-zinc ore predominated, the former being nearly 69 per cent of the total and the latter more than 21 per cent. Copper ore constituted more than 3 per cent of the total; zinc ore, nearly 5 per cent; and siliceous ore, about 2 per cent. Much of the lead ore contains zinc that is not saved, but more zinc is being saved each year. The total ore mined and treated had an average value per ton, in gold and silver, of $2.72; the siliceous ore, $9.39; the copper ore, $2.27; the lead ore, $3.03; the lead-zinc ore, $1.59; and the zinc ore, 63 cents. The siliceous ore sold or treated averaged per ton as follows: Gold, $8.67; silver, 1.42 ounces. The siliceous ore included 51,786 tons of gold ore, averaging per ton $8.65 in gold and 0.88 ounce of silver; 119 tons of gold and silver ore, averaging per ton $15.77 in gold and 36.59 ounces of silver; and 397 tons of silver ore, averaging per ton $8.48 in gold, 61.64 ounces of silver, 5.96 pounds of copper, and 4.82 pounds of lead. The copper ore averaged per ton $1.10 in gold and 2.30 ounces of silver, and contained 3.68 per cent of copper and 0.005 per cent of lead. The averages of copper ore and concentrate shipped, as well as those of lead and zinc ores, are given after the tables showing contents of crude ore and concentrates. Lead ore as mined averaged 3 cents in gold and 5.91 ounces of silver per ton, and contained 0.04 per cent of copper and 8.88 per cent of lead. The zinc ore averaged per ton 0.2 cent in gold and 1.24 ounces of silver, and contained 1.70 per cent lead and 10.07 per cent zinc (spelter). Lead-zinc ore averaged per ton 2 cents in gold and 3.09 ounces of silver, and contained 0.06 per cent copper, 4.64 per cent lead, and 4.64 per cent zinc.

The output of copper ore continued to decrease, but the production of siliceous ore, lead ore, and zinc ore was much greater.

Ore sold or treated in Idaho in 1915, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Ada	97						97
Adams	1,320	164					1,484
Bannock			5				5
Blaine	2,134		3,006	221		5,199	10,560
Boise	18,381	27					18,408
Bonner	158	25	468				651
Bonneville		16					16
Boundary			10,212				10,212
Cassia			89	52			141
Clearwater	15						15
Custer	42	54,671	91				54,804
Elmore	15,499						15,499
Fremont			10,969				10,969
Gem	62						62
Idaho	4,133		22				4,155
Lemhi	9,328	734	15,496		2		25,560
Nez Perce	1						1
Owyhee	732						732
Shoshone	400	19,264	1,616,330	111,155		508,326	2,255,475
	[a]52,302	74,901	1,656,688	111,428	2	513,525	2,408,846
Average per ton in gold and silver	$9.39	$2.27	$3.03	$0.63	$7.50	$1.59	$2.72

[a] Includes 51,786 tons of gold ore, 119 tons of gold and silver ore, and 397 tons of silver ore.

A little more than 2 per cent of the ore, 51,099 tons, was treated in gold and silver mills in 1915, against 34,861 tons in 1914. Bullion from this ore treated by amalgamation or cyanidation was valued at $424,003, or $8.30 a ton of ore. There was a general increase in the quantity of ores treated by amalgamation, Boise County taking the lead and Elmore County following. At these mills during 1915 about 1,040 pounds of mercury and 6,619 pounds of potassium and sodium cyanide were consumed. The average consumption of quicksilver was 0.022 pound per ton of ore amalgamated and 0.027 pound per ounce of gold and silver bullion saved. The cyanide consumption was 1.41 pounds per ton of ore treated and 0.44 pound per ounce of gold and silver bullion recovered.

Gold and silver produced in mills in Idaho in 1915.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Ada	97	30.35	27	23.06	124	$1,189
Adams	1,320			314.62	56	6,533
Blaine	[a]2,019	704.74	322			14,731
Boise	[b]18,311	7,795.63	2,307	7.79	46	162,504
Clearwater	15	5.57	2			116
Custer	14	1.93	1	5.85	44	184
Elmore	15,448	2,873.28	1,437	472.53	1,975	70,894
Idaho	[c]4,097	2,793.66	1,027	217.04	48	62,782
Lemhi	8,701	1,498.47	456	530.93	684	42,529
Nez Perce	1	.72				15
Owyhee	[d]676	2,146.16	14,594	146.17	10,383	60,050
Shoshone	[e]400	119.26	39			2,485
	51,099	17,969.77	20,212	1,717.99	13,360	424,003

[a] Also yielded 57 tons of concentrates.
[b] Also yielded 83 tons of concentrates.
[c] Also yielded 22 tons of concentrates.
[d] Also yielded 2 tons of concentrates.
[e] Also yielded 3 tons of concentrates.

Of the ore produced, 2,184,485 tons, or nearly 91 per cent, was concentrated. Concentrates from this ore from old tailings treated and from a small quantity of ore worked in gold and silver mills aggregated 336,616 tons, valued at $24,684,259, or $73.33 a ton in 1915, against $57.85 in 1914. The concentrates were largely from the Coeur d'Alene region, and the ratio was 6.5 tons of ore to 1 ton of concentrate. Nearly 76 per cent of the total was lead concentrate, nearly 21 per cent zinc concentrate, and less than 3 per cent was lead-zinc concentrate. Siliceous and copper concentrates were relatively unimportant. An increase of 50 per cent was made in zinc concentrates alone, as well as good increase in lead and lead-zinc concentrates. Shoshone County shipped an average of 27,460 tons of concentrates of various kinds per month. The crude ore shipped, which was 7,930 tons per month, being added gives the Coeur d'Alene region average monthly shipments of 35,390 tons of concentrates and crude ore.

Mine production of metals from Idaho concentrates in 1915.

By counties.

	Ore to concentrating mills.	Concentrates produced.						Total value of concentrates.
		Quantity.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Blaine	7,467	1,182	469.06	53,548	1,311	587,120	299,461	$101,801
Boise	.....	120	434.48	2,570	330	8,049	.....	10,721
Bonner	457	110	.08	1,455	74	163,308	.....	8,428
Boundary	9,678	1,613	12.20	50,199	4,176	1,969,948	.....	119,074
Fremont	10,214	3,912	2.90	30,260	6,181	4,186,019	.....	213,227
Idaho	.....	22	147.09	116	.....	64	.....	3,103
Lemhi	623	125	225.28	756	87,957	.....	.....	20,432
Owyhee	.....	2	12.37	1,295	.....	.....	.....	912
Shoshone	2,156,046	329,530	1,417.58	8,431,322	1,446,712	257,855,890	60,727,218	24,206,561
	2,184,485	336,616	2,721.04	8,571,521	1,547,041	264,770,398	61,026,679	24,684,259

By kinds of concentrates.

Dry or siliceous	167	840.13	3,752	46	64	.....	$19,280
Copper	1,607	243.51	31,989	572,466	.....	.....	121,433
Lead	255,621	1,607.35	8,254,500	974,529	258,896,826	.....	16,556,953
Zinc	69,581	30.05	149,385	.....	4,192,216	54,026,455	6,972,673
Lead-zinc	9,640	.....	131,895	.....	1,681,292	7,000,224	1,013,920

The concentrates had the following average contents: Siliceous concentrates contained $103.99 in gold and 22.47 ounces of silver, or $115.45 per ton. Copper concentrates contained $3.12 in gold and 19.91 ounces of silver per ton, and also 17.81 per cent copper, a total value per ton of $75.56. Lead concentrates averaged 13 cents in gold and 32.3 ounces of silver per ton and 0.19 per cent copper and 50.06 per cent lead, or a total per ton of $64.77. Zinc concentrates averaged 1 cent in gold and 2.15 ounces of silver per ton and 3.01 per cent lead and 38.82 per cent zinc (spelter), or a total per ton of $100.21. Lead-zinc concentrates averaged 13.68 ounces of silver and 8.72 per cent lead and 36.30 per cent zinc (spelter), or a total per ton of $105.17. Averages for concentrates, as well as for shipping ore, from 1911 to 1914 were given in a previous report.[1]

Of the total ore, 169,402 tons, or more than 7 per cent, was shipped crude to smelters. A large part of this ore in Shoshone and Fremont counties is picked from the belts as it comes into the mills. With the exception of a small quantity of ore smelted at the Lost Packer mine, in Custer County, all this ore went to plants outside the State. Shoshone, Custer, Lemhi, Blaine, and Fremont counties supplied most of it, and the shipping ore contained metals valued at $7,632,769, or $45.06 a ton. There was a marked increase in all kinds of shipping products except siliceous ore and lead-zinc ore. The greatest increase was in copper ore from Custer County; and as this is a low-grade ore, it accounts for the decrease in average value per ton of shipping ore. Nearly 60 per cent of the crude ore shipped was lead ore, 33 per cent was copper ore, and more than 6 per cent was zinc ore. The combined value of the concentrates and the crude ore shipped, nearly all of which went to distant smelters, was $32,317,028. The crude ore smelted was principally sulphide in character. A close separation of oxidized and sulphide portions, with average content per ton, is as follows: Copper ore shipped consisted of 18,451 tons of oxidized and carbonate ore averaging $1.23 in gold and 2.34 ounces of silver per ton, and also 4.53 per cent copper, or a total value per ton of $18.30, and of 37,400 tons of sulphide ore, averaging $1.46 in gold and 2.59 ounces of silver per ton and 4.36 per cent copper, or a total per ton of $18.05. There was a greater difference in the lead ore, for the oxidized portion—15,975 tons—averaged 69 cents in gold and 13.27 ounces of silver per ton and 0.25 per cent copper, 28.22 per cent lead, or a total value per ton of $34.82; and the sulphide lead ore shipped—85,229 tons—averaged 17 cents in gold and 32.15 ounces of silver per ton and 0.24 per cent copper and 41.97 per cent lead, or a total value per ton of $56.77. A small quantity of oxidized zinc ore averaged 25.47 per cent spelter, and 10,616 tons of sulphide ore shipped contained 43.68 per cent spelter and 2.90 per cent lead. All the lead-zinc ore shipped was sulphide.

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 601, 1915.

Mine production of metals from Idaho crude ore shipped to smelters in 1915.

By counties.

	Crude ore to smelter.						Total value.
	Quantity.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Adams	164	9.16	671	58,694	.....	.....	$10,800
Bannock	5	.....	4	112	4,126	.....	216
Blaine	1,074	171.22	28,596	1,660	410,943	142,275	55,286
Boise	97	76.11	1,500	2,875	843	.....	2,877
Bonner	194	25.17	12,194	9,649	2,427	.....	8,504
Bonneville	16	.97	32	824	.....	.....	180
Boundary	534	4.34	14,549	1,711	530,452	.....	32,697
Cassia	141	43.59	2,003	2,028	45,056	26,495	7,676
Custer	54,790	4 045.17	142,545	4,767,025	42,786	.....	992,131
Elmore	51	61.10	2,696	.....	.....	.....	2,630
Fremont	755	.....	6,040	.....	845,600	.....	42,805
Gem	62	119.49	2,683	.....	1,748	.....	3,913
Idaho	58	183.23	1,779	1,284	11,337	.....	5,447
Lemhi	16,236	847.90	205,091	91,226	8,791,046	.....	550,653
Owyhee	56	160.10	10,138	.....	.....	.....	8,450
Shoshone	95,169	619.09	2,727,579	494,584	70,542,704	8,957,785	5,908,504
	169,402	6,366.64	3,158,100	5,431,672	81,229,068	9,126,555	7,632,769

By kinds of ore.

Dry or siliceous	1,203	1,354.01	36,751	4,285	3,662	.....	$47,545
Copper	55,851	3,753.85	139,942	4,937,961	843	.....	1,012,733
Lead	101,204	1,250.46	2,952,137	488,962	80,559,167	.....	5,394,432
Zinc	10,668	8.30	22,343	.....	617,063	8,764,324	1,127,277
Copper-lead	2	.02	27	464	559	.....	122
Lead-zinc	474	.....	6,900	.....	47,774	362,231	50,660

The crude ore shipped had the following averages: Siliceous ore averaged per ton $23.27 in gold and 30.55 ounces of silver and 0.17 per cent copper and 0.15 per cent lead, or a total value per ton of $39.52; copper ore, $1.39 in gold and 2.51 ounces of silver per ton, and 4.42 per cent copper and a trace of lead, or a total value per ton of $18.13; lead ore, 26 cents in gold and 29.17 ounces of silver per ton, and 0.24 per cent copper and 39.80 per cent lead, or a value per ton of $53.30; zinc ore, 2 cents in gold and 2.09 ounces of silver per ton, and 2.89 per cent lead and 41.08 per cent zinc, or a value per ton of $105.67; lead-zinc ore, 14.56 ounces of silver per ton and 5.39 per cent lead and 38.21 per cent zinc, or a total value per ton of $106.87.

GOLD.

The mine production of gold in 1915 was 57,069.49 fine ounces, valued at $1,179,731, an increase of $27,416, or more than 2 per cent. Boise and Lemhi counties remained the largest producers of gold, although there was a considerable decrease in both counties, especially in Lemhi. However, most of the counties showed increase, Elmore and Idaho, especially. The lode mines, 226 in number, produced gold valued at $594,841; and 186 placers produced gold valued at $584,890, against 208 placers and $700,454 in 1914. Of the placer gold, $486,541, or more than 83 per cent, was won by 7 dredges;

$1,986 by drift mines; and $96,363 by hydraulic or sluicing mines. The dredge output in 1915 decreased $82,448 from that of 1914, and gold from sluicing and hydraulicking $34,088. Of the total gold, nearly 50 per cent came from placers, more than 38 per cent from siliceous ore, 4 per cent from lead ore, 7 per cent from copper ore, and nearly 1 per cent from lead-zinc ore. Siliceous ore contained $8.67 a ton in gold, copper ore $1.10, lead ore 3 cents, copper-lead ore 50 cents, and lead-zinc ore 2 cents. Snake River in various counties produced $5,721 in gold and 23 ounces of silver. After several years of decrease there was a revival in the production of gold from amalgamation and cyanidation mills. In 1915 bullion recovered at these mills contained 19,687.76 ounces of gold, or 34 per cent of the total, against 12,284.02 ounces in 1914. Amalgamation won 17,969.77 ounces of gold and cyanidation 1,717.99 ounces. Concentrates of all kinds contained only 2,721.04 ounces of gold, or about 5 per cent of the total gold, an average per ton of 17 cents. Siliceous concentrates contained $103.99 a ton in gold. Crude ore shipped to smelters contained 6,366.64 ounces of gold, or more than 11 per cent of the total. The smelting ore averaged per ton in gold 78 cents; the siliceous ore smelted, $23.27; the copper ore, $1.39; and the lead ore, 26 cents. Various sulphide shipping ores contained 3,381.33 ounces of gold and oxidized ores contained 2,985.30 ounces. A statement of the dredges operated since 1897 and their output by years was given in a former report.[1] A total in gold of $3,394,360 has been recovered by dredges.

Mine production of gold in Idaho in 1915, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Ada	92.78	53.41	.....	.....	.....	.....	.....	146.19
Adams	20.17	314.63	9.15	.....	.....	.....	.....	343.95
Benewah	235.00	.....	.....	.....	.....	.....	.....	235.00
Bingham	37.25	.....	.....	.....	.....	.....	.....	37.25
Blaine	2.95	1,085.17	.....	131.45	8.27	.....	120.13	1,347.97
Boise	18,540.16	8,309.79	4.22	.....	.....	.....	.....	26,854.17
Bonner	9.00	23.67	1.01	.57	.....	.....	.....	34.25
Bonneville	218.27	.....	.97	.....	.....	.....	.....	219.24
Boundary	.....	.....	.....	16.54	.....	.....	.....	16.54
Canyon	18.29	.....	.....	.....	.....	.....	.....	18.29
Cassia	.....	.....	.....	43.59	.....	.....	.....	43.59
Clearwater	1,356.48	5.57	.....	.....	.....	.....	.....	1,362.05
Custer	49.05	413.65	3,639.19	.11	.....	.....	.....	4,102.00
Elmore	323.48	3,406.91	.....	.....	.....	.....	.....	3,730.39
Fremont	.....	.....	.....	2.90	.....	.....	.....	2.90
Gem	12.43	119.49	.....	.....	.....	.....	.....	131.92
Gooding	43.92	.....	.....	.....	.....	.....	.....	43.92
Idaho	1,360.84	3,309.97	.....	31.05	.....	.....	.....	4,701.86
Latah	31.88	.....	.....	.....	.....	.....	.....	31.88
Lemhi	5,711.20	2,302.36	279.15	521.02	.....	.05	.....	8,816.78
Minidoka	8.61	.....	.....	.....	.....	.....	.....	8.61
Nez Perce	2.47	.72	.....	.....	.....	.....	.....	3.19
Owyhee	12.29	2,161.80	.....	.....	.....	.....	.....	2,177.09
Power	33.86	.....	.....	.....	.....	.....	.....	33.86
Shoshone	90.27	125.31	63.61	1,559.05	.....	.....	407.93	2,246.20
Twin Falls	80.40	.....	.....	.....	.....	.....	.....	80.40
	28,294.05	[a]21,935.45	3,997.33	2,306.28	8.27	.05	528.06	57,069.49

[a] Includes 21,681.77 ounces from gold ore, 90.81 ounces from gold and silver ore, and 162.87 ounces from silver ore.

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 604, 1915.

SILVER.

The mine production of silver decreased from 12,479,516 ounces, valued at $6,901,172, in 1914 to 11,769,128 ounces, valued at $5,966,948, in 1915, a decrease of nearly 6 per cent. The rate of decrease was greater than this in the Coeur d'Alene region, but increase in other regions reduced the net loss. There was a decrease in the output of silver from lead-zinc ore and from copper ore, but good increase from lead ore, zinc ore, and siliceous ore. The largest part of the total silver yield, or 83 per cent, was from lead ore, 13 per cent from lead-zinc ore, more than 1 per cent from copper ore, and less than 1 per cent from siliceous ore. Shoshone County produced nearly 95 per cent of the silver. The largest increases were in Lemhi, Boundary, and Custer counties. Concentrates supplied nearly 73 per cent of the silver; crude ore contained nearly 27 per cent; and gold and silver bullion contained only 0.29 per cent. Crude ore averaged 18.64 ounces a ton and concentrates 25.46 ounces a ton. The oxidized portion of the crude ore shipped contained 291,923 ounces of silver and the sulphide 2,866,177 ounces. Difficulty in renewing smelter contracts at former rates had the effect of curtailing the production of silver.

Mine production of silver in Idaho in 1915, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Ada	19	151						170
Adams	8	56	671					735
Bannock				4				4
Benewah	26							26
Bingham	3							3
Blaine		948		58,142	551		22,825	82,466
Boise	4,563	6,017	406					10,986
Bonner	2	11,000	14	2,635				13,651
Bonneville	7		32					39
Boundary				64,748				64,748
Canyon	5							5
Cassia				2,003				2,003
Clearwater	385	2						387
Custer	11	7,378	134,291	921				142,601
Elmore	87	6,108						6,195
Fremont				36,300				36,300
Gem	3	2,683						2,686
Gooding	2							2
Idaho	292	2,354		616				3,262
Latah	4							4
Lemhi	449	1,333	1,595	204,032		27		207,436
Minidoka	2							2
Owyhee	42	36,410						36,452
Power	2							2
Shoshone	15	41	34,922	9,422,543	137,912		1,563,522	11,158,955
Twin Falls	8							8
	5,935	[a] 74,481	171,931	9,791,944	138,463	27	1,586,347	11,769,128

[a] Includes 45,556 ounces from gold ore, 4,354 ounces from gold and silver ore, and 24,571 ounces from silver ore.

COPPER.

The mine production of copper increased from 6,445,187 pounds, valued at $857,210, in 1914 to 6,978,713 pounds, valued at $1,221,275, in 1915—an increase of more than 8 per cent. However, this was much less than the output of 1913—9,592,966 pounds. There was

decrease in Shoshone County of 2,301,366 pounds on account of the closing of the Snow Storm mine, and increase in Custer County of 2,656,116 pounds due to efforts made at the Empire property to take advantage of the improved copper market the latter part of the year. The National mine, near Mullan, was not an important contributor. Nearly 79 per cent of the total output of copper was from copper ore, 20 per cent from lead ore, and 1 per cent from lead-zinc ore. The production instead of being nearly evenly divided between that from crude ore and that from concentrates as in 1914, was in 1915 largely from crude ore, which supplied nearly 78 per cent of the total. Concentrates contained more than 22 per cent. Crude copper ore shipped averaged 4.42 per cent copper, and copper concentrates 17.80 per cent. Sulphide ore shipped contained 3,673,482 pounds of copper and oxidized ore, 1,758,190 pounds.

Mine production of copper in Idaho in 1915, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Adams	.....	58,694	.....	.....	.....	58,694
Bannock	.....	.....	112	.....	.....	112
Blaine	1,084	.....	1,288	.....	599	2,971
Boise	330	2,875	.....	.....	.....	3,205
Bonner	2,250	7,399	74	.....	.....	9,723
Bonneville	.....	824	.....	.....	.....	824
Boundary	.....	.....	6,187	.....	.....	6,187
Cassia	.....	.....	2,028	.....	.....	2,028
Custer	.....	4,765,687	1,338	.....	.....	4,767,025
Fremont	.....	.....	6,181	.....	.....	6,181
Idaho	997	.....	287	.....	.....	1,284
Lemhi	.....	99,450	79,269	464	.....	179,183
Shoshone	.....	575,498	1,297,197	.....	68,601	1,941,296
	[a] 4,661	5,510,427	1,393,961	464	69,200	6,978,713

[a] Includes 2,295 pounds from gold ore and 2,366 pounds from silver ore.

LEAD.

The mine production of lead decreased from 348,526,069 pounds, valued at $13,592,517, in 1914 to 345,999,466 pounds, valued at $16,261,975, in 1915. The decrease in quantity was nearly 1 per cent. Part of the decrease in Shoshone County was offset by increase in Lemhi, Boundary, and Fremont counties. Lead ore supplied more than 85 per cent of the total, lead-zinc ore nearly 14 per cent, and zinc ore a little more than 1 per cent. There was proportionately more lead from lead ore and zinc ore, but less from lead-zinc ore. The recoverable lead in all ores sold or treated averaged 7.18 per cent; that in lead ore, 8.88 per cent; and that in lead-zinc ore, 4.64 per cent. Crude lead ore shipped averaged 39.80 per cent of recoverable lead, and lead concentrates, 50.06 per cent. Concentrates of all kinds produced nearly 77 per cent of the total. Lead concentrates had an average value per ton of $64.77. Crude ore shipped was the source of 23 per cent of the lead, and the lead ore shipped to smelter had an average value per ton of $53.30. Nearly all the lead in crude ore shipped was from sulphide ores, only 9,022,139 pounds coming from oxidized ores.

Mine production of lead in Idaho in 1915, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Bannock			4,126				4,126
Blaine	2,690		675,726	2,303		317,344	998,063
Boise	8,049	843					8,892
Bonner			165,735				165,735
Boundary			2,500,400				2,500,400
Cassia			45,056				45,056
Custer			42,786				42,786
Fremont			5,031,619				5,031,619
Gem	1,748						1,748
Idaho	172		11,229				11,401
Lemhi			8,790,487		559		8,791,046
Shoshone			277,284,768	3,779,160		47,334,666	328,398,594
	a 12,659	843	294,551,932	3,781,463	559	47,652,010	345,999,466

a Includes 10,745 pounds from gold ore and 1,914 pounds from silver ore.

ZINC.

The mine production of zinc (calculated as spelter) increased from 42,012,435 pounds, valued at $2,142,634, in 1914 to 70,153,234 pounds, valued at $8,699,001, in 1915. This increase of nearly 67 per cent came almost entirely from the Coeur d'Alene region and in great part from the Consolidated Interstate Callahan property, which is the greatest zinc mine of the State. Zinc products continued to come from near Hailey, in Blaine County, and a new deposit of oxidized ore was opened near Black Pine, in Cassia County. Although zinc was considered unimportant a few years ago, it is interesting to note that the value of the output in the State in 1915 was greater than the combined value of the gold, silver, and copper. Lead-zinc ore supplied about 68 per cent and zinc ore about 32 per cent of the zinc. Both the zinc concentrates and the crude zinc ore shipped are sulphide products, except the ore from Cassia County. From concentrates, both zinc and lead-zinc, 61,026,679 pounds of recoverable spelter were won, or 87 per cent of the total; and from crude ore shipped 9,126,555 pounds were won, or 13 per cent of the total. Flotation, in addition to wet concentration, for the saving of both lead and zinc is used at many of the large mills in Shoshone County. Roasting and magnetic separation were used at the Success and Frisco mills.

Mine production of zinc (spelter) in Idaho in 1915, in dry pounds.

County.	Lead ore.	Zinc ore.	Lead-zinc ore.	Total.
Blaine		142,275	299,461	441,736
Cassia		26,495		26,495
Shoshone	52,299	22,267,840	47,364,864	69,685,003
	52,299	22,436,610	47,664,325	70,153,234

The sources of the ore and the actual assay in zinc, without deduction for losses in smelting, are shown below. There were 90,363 tons of zinc ore, zinc concentrates, lead-zinc ore, and lead-zinc concentrates shipped, of which the gross assay content was 82,521,106 pounds of zinc, or an average of 45.66 per cent. A small part of the output came from Blaine and Cassia counties, but most of it came

from the Beaver, Hunter, Lelande, Placer Center, Summit, and Yreka districts in Shoshone County. In 1914 the shipments were 54,754 tons of zinc ore and concentrates, containing 49,460,215 pounds of zinc, or an average of 45.17 per cent.

Zinc ore, lead-zinc ore, and concentrates produced from Idaho mines sold in 1915.

County.	Classification.	Quantity (short tons, dry weight).	Average assay of ore and concentrate.[a]
			Per cent of zinc.
Blaine and Shoshone	Sulphide zinc ore and concentrates	80,197	46.03
Shoshone	Sulphide lead-zinc ore and concentrates	10,114	42.82
Cassia	Carbonate zinc ore	52	29.97
		90,363	45.66

[a] Actual zinc content.

REDUCTION PLANTS.

There were 75 milling plants of all kinds in operation in Idaho in 1915, of which many were active for short periods, against 64 active mills in 1914. Of these mills, 32 were concentration plants, 12 of which used flotation machines, and 2 used roasting and magnetic separation. Twenty-three mills used amalgamation alone; 7 used cyanidation; 10 amalgamation and concentration; and 3 amalgamation and cyanidation. No smelting plants were operated, except a small matting plant in Custer County. A lead plant was under construction at Northport, Wash., where it is planned to treat ore and concentrates from the Cœur d'Alene region, as well as custom material. Early in 1916 plans were formulated by the Bunker Hill & Sullivan Co. for the construction of a lead plant at Kellogg, Idaho.

MINING INDUSTRY.

Mining conditions in Idaho were quiet during the first half of 1915. From the low marks of 1914 prices for metals, particularly those of zinc, copper, and lead, began gradually to increase. The mines were quick to respond, and if local troubles in regard to smelter contracts had not occurred there would have been a record production of silver and lead, as well as of zinc. The controversy between the Hercules Mining Co. and the smelting company closed the mine and mill of one of the most important lead-silver producers for three months. The smelting situation has thereby been changed, for the Hercules Co. immediately began the construction of a smelting plant at Northport, Wash., and the Bunker Hill & Sullivan Co. announced its intention of building a large smelter to treat company and custom ore. Many of the mines made better saving and reduced costs by the use of flotation. Electricity available from Thompson Falls, Mont., has also reduced the cost of power. The main accomplishment in railroad building was the completion by the Intermountain Railway Co. of a road built primarily to haul lumber from the Boise Basin district to Barberton, near Boise. Efforts were made to have branch roads built into the Pine Creek and the Beaver Creek sections in the Cœur d'Alene region. Compared with other States, Idaho in 1915 was second in lead, fourth in silver, and fifth in zinc.

Mine production of metals in Idaho in 1915.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total value.	Quantity.	Value.
	Quantity.	Value.	Quantity.	Value.			
	Fine ounces.		*Fine ounces.*			*Fine ounces.*	
Ada	92.78	$1,918	53.41	$1,104	$3,022	170	$86
Adams	20.17	417	323.78	6,693	7,110	735	373
Bannock						4	2
Benewah	235.00	4,858			4,858	26	13
Bingham	37.25	770			770	3	1
Blaine	2.95	61	1,345.02	27,804	27,865	82,466	41,810
Boise	18,540.16	383,259	8,314.01	171,866	555,125	10,986	5,570
Bonner	9.00	186	25.25	522	708	13,651	6,921
Bonneville	218.27	4,512	.97	20	4,532	39	20
Boundary			16.54	342	342	64,748	32,827
Canyon	18.29	378			378	5	3
Cassia			43.59	901	901	2,003	1,016
Clearwater	1,356.48	28,041	5.57	115	28,156	387	196
Custer	49.05	1,014	4,052.95	83,782	84,796	142,601	72,299
Elmore	323.48	6,687	3,406.91	70,427	77,114	6,195	3,141
Fremont			2.90	60	60	36,300	18,404
Gem	12.43	257	119.49	2,470	2,727	2,686	1,362
Gooding	43.92	908			908	2	1
Idaho	1,360.84	28,131	3,341.02	69,065	97,196	3,262	1,654
Latah	31.88	659			659	4	2
Lemhi	5,714.20	118,123	3,102.58	64,136	182,259	207,436	105,170
Minidoka	8.61	178			178	2	1
Nez Perce	2.47	51	.72	15	66		
Owyhee	12.29	254	2,464.80	50,952	51,206	36,452	18,481
Power	33.86	700			700	2	1
Shoshone	90.27	1,866	2,155.93	44,567	46,433	11,158,955	5,657,590
Twin Falls	80.40	1,662			1,662	8	4
	28,294.05	584,890	28,775.44	594,841	1,179,731	11,769,128	5,966,948

County.	Copper.		Lead.		Zinc (spelter).		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Ada							$3,108
Adams	58,694	$10,271					17,754
Bannock	112	20	4,126	$194			216
Benewah							4,871
Bingham							771
Blaine	2,971	520	998,063	46,909	441,736	$54,775	171,879
Boise	3,205	561	8,892	418			561,674
Bonner	9,723	1,701	165,735	7,789			17,119
Bonneville	824	144					4,696
Boundary	6,187	1,083	2,500,400	117,519			151,771
Canyon							381
Cassia	2,028	355	45,056	2,118	26,495	3,286	7,676
Clearwater							28,352
Custer	4,767,025	834,229	42,786	2,011			993,335
Elmore							80,255
Fremont	6,181	1,082	5,031,619	236,486			256,032
Gem			1,748	82			4,171
Gooding							909
Idaho	1,284	225	11,401	536			99,611
Latah							661
Lemhi	179,183	31,357	8,791,046	413,179			731,965
Minidoka							179
Nez Perce							66
Owyhee							69,687
Power							701
Shoshone	1,941,296	339,727	328,398,594	15,434,734	69,685,003	8,640,940	30.119.424
Twin Falls							1,666
	6,978,713	1,221,275	345,999,466	16,261,975	70,153,234	8,699,001	33,328.930

Many of the counties of the State showed decrease in placer output, and, except in Clearwater County, dredge operations were smaller than in 1914.

Producing placer mines and production in Idaho, in 1914 and 1915.

County.	1914						1915					
	Mines.			Gold.	Silver.	Total value.	Mines.			Gold.	Silver.	Total value.
	Hydraulic.	Dredge.	Drift.				Hydraulic.	Dredge.	Drift.			
					Fine ounces.						*Fine ounces.*	
Ada	5	....	....	$2,533	27	$2,548	2	....	....	$1,918	19	$1,928
Adams	2	....	....	383	3	385	1	....	....	417	8	421
Benewah	....	....	....	....	....	....	2	....	....	4,858	26	4,871
Bingham	3	....	....	906	3	908	1	....	....	770	3	771
Blaine	3	....	....	148	1	149	2	....	....	61	....	61
Boise	43	1	1	472,692	5,711	475,850	33	1	....	383,259	4,563	385,572
Bonner	....	....	....	....	....	....	2	....	....	186	2	187
Bonneville	2	....	....	3,937	4	3,939	4	....	....	4,512	7	4,516
Canyon	....	....	....	....	....	....	4	....	....	378	5	381
Clearwater	14	1	....	18,689	219	18,811	15	2	....	28,041	385	28,236
Custer	12	....	....	4,190	86	4,237	7	....	....	1,014	11	1,020
Elmore	14	....	....	9,588	135	9,663	13	....	....	6,687	87	6,731
Gem	....	....	....	....	....	....	2	....	....	257	3	258
Gooding	1	....	....	641	2	642	4	....	....	908	2	909
Idaho	64	....	2	20,310	212	20,427	46	1	6	28,131	292	28,279
Kootenai	1	....	....	2,620	10	2,625	....	....	....	....	....	....
Latah	4	....	....	700	3	702	3	....	....	659	4	661
Lemhi	12	2	....	158,255	620	158,597	10	2	....	118,123	449	118,351
Minidoka	....	....	....	....	....	....	1	....	....	178	2	179
Nez Perce	1	....	....	14	....	14	....	....	1	51	....	51
Owyhee	4	....	....	1,542	11	1,548	4	....	....	254	42	275
Power	3	....	....	698	6	701	2	1	....	700	2	701
Shoshone	9	....	....	2,060	15	2,068	9	....	....	1,866	15	1,874
Twin Falls	4	....	....	548	3	550	5	....	....	1,662	8	1,666
	201	4	3	700,454	7,071	704,364	172	7	7	584,890	5,935	587,899

Ore sold or treated, deep mines producing, and average value of ores in Idaho.

County.	Ore sold or treated, 1915.		Number of deep mines producing.		Average total value per ton.[a]		Average value per ton in gold and silver.[a]	
	Quantity.	Increase or decrease.	1914	1915	1914	1915	1914	1915
	Short tons.	*Short tons.*						
Ada	97	+ 94	1	4	$21.33	$12.16	$21.33	$12.16
Adams	1,484	+ 460	2	5	8.17	11.68	4.02	4.76
Bannock	5	+ 5	....	1	....	43.20	....	.40
Blaine	10,560	+ 2,857	36	33	16.92	16.27	7.99	6.59
Boise	18,408	+ 1,341	15	15	7.79	9.57	7.78	9.51
Bonner	651	+ 193	6	7	28.94	26.01	8.77	11.43
Bonneville	16	+ 16	....	1	....	11.25	....	2.25
Boundary	10,212	+ 10,212	....	1	....	14.86	....	3.25
Cassia	141	+ 127	1	3	9.21	54.44	7.00	13.59
Clearwater	15	+ 9	2	1	22.83	7.73	22.83	7.73
Custer	54,804	+ 33,014	10	14	17.87	18.11	4.37	2.85
Elmore	15,499	+ 12,260	8	11	3.40	4.74	3.40	4.74
Fremont	10,969	+ 2,702	2	1	21.89	23.34	1.27	1.68
Gem	62	+ 62	....	2	....	63.11	....	61.79
Idaho	4,155	− 164	31	32	5.73	17.17	5.53	16.98
Lemhi	25,560	+ 8,010	18	37	17.16	24.00	10.64	6.61
Nez Perce	1	+ 1	....	1	....	15.00	....	15.00
Owyhee	732	− 909	15	14	13.59	94.82	13.59	94.82
Shoshone	2,255,475	+103,207	29	43	10.56	13.35	3.16	2.53
	2,408,846	+173,497	176	226	10.71	13.59	3.29	2.72

[a] Value per ton, placer product excluded.

Classifying the deep mines according to metals produced in 1915 shows that there were 3 mines producing gold only; 111 gold and silver; 24 gold, silver, and copper; 33 gold, silver, copper, and lead; 6 gold, silver, copper, lead, and zinc; 17 gold, silver, and lead; 11 silver and lead; 6 silver, lead, and zinc; 4 silver, copper, and lead; 2 silver and copper; 5 zinc; and 3 gold, silver, lead, and zinc.

REVIEW BY COUNTIES.

ADA COUNTY.

Six properties produced $3,022 in gold and 170 ounces of silver, in all valued at $3,108. Little work was done on the various properties in the Black Hornet district, and the Monitor placer group in the Highland district produced most of the gold. Further development at depth was planned at the Ironsides mine, 8 miles east of Boise, which has a good mine plant and a 20-stamp mill.

ADAMS COUNTY.

Six properties produced 1,484 tons of ore containing $7,110 in gold, 735 ounces of silver, and 58,694 pounds of copper, in all valued at $17,754. The ore had a value per ton of $11.68 and consisted of oxidized copper ore and siliceous gold ore, which was treated by cyanidation.

Seven Devils district.[1]—This district, near Landore, produced most of the county output. A 50-ton cyanide plant was operated for about 30 days at the Idaho Gold Coin property. Copper ore was shipped from the Blue Jacket, Arkansas, South Peacock, and the National properties. At the Red Ledge property, 16 miles from Homestead, a 400-foot adit continued to open a low-grade copper deposit.

Unorganized or Meadows district.—Some placer gold came from the vicinity of Meadows.

BANNOCK COUNTY.

In the Portneuf district the Lead Bell property produced a small shipment of lead ore. The Fort Hall and Moonlight properties in the Fort Hall district were being developed and will ship copper ore in 1916.

BENEWAH COUNTY.

In 1915 Benewah County was formed from the southern part of Kootenai County. The Camas Cove district, in the vicinity of Tyson, produced placer gold from the Cedar Creek property.

BINGHAM COUNTY.

Placer operations in Snake River resulted in the production of $770 in gold and 3 ounces of silver. An article[2] on the Snake River

[1] Lindgren, Waldemar, Copper deposits of the Seven Devils, Idaho: U. S. Geol. Survey Twentieth Ann. Rept., pt. 3, p. 249, 1900.

[2] Hill, J. M., Notes on the fine gold of Snake River, Idaho: U. S. Geol. Survey Bull. 620, pp. 271–294, 1915 (Bull. 620–L).

gold giving the history, methods of mining, productive localities, and bibliography was recently published.

BLAINE COUNTY.

Mine production in Blaine County, Idaho, in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	39	7,703	$14,019	86,234	9,089	1,093,676	489,052	$130,516
1915	35	10,560	27,865	82,466	2,971	998,063	441,736	171,879
Increase or decrease, 1915		+2,857	+13,846	−3,768	−6,118	−95,613	−47,316	+41,369
Total, 1880–1915			2,436,821	15,347,824	147,868	178,991,635	4,141,253	24,230,980

Thirty-three deep mines produced 2,857 tons more ore than 36 mines in 1914. The ore had a value per ton of $16.27 in all metals and a value of $6.59 in gold and silver. The output was divided into 5,199 tons of lead-zinc ore, 3,006 tons of lead ore, 2,134 tons of siliceous ore, and 221 tons of zinc ore. Of the total quantity, 7,467 tons were concentrated, 1,074 tons were shipped directly to smelters, and 2,019 tons were treated at gold and silver mills by amalgamation. The crude ore smelted had a value of $55,286, or $51.48 per ton, and the concentrates had a value of $101,801, or $86.13 per ton. Since 1880 the county has produced gold, silver, copper, lead, and zinc valued at $24,230,980, of which $13,903,341 represented silver, $7,604,844 lead, $2,436,821 gold, $263,686 zinc, and $22,288 copper. The production by years was given in the report[1] for 1914. Regarding new development, the mine inspector[2] reported:

> In the Wood River district several important strikes were recorded among the old lead-ore deposits—one of them in the Lipman tunnel, at one of the deepest points reached in the district and supposed to be on the original channel of the Red Elephant vein. A 10-foot body of rich lead-silver concentrating ore has been cut and is attracting a great deal of attention, as it seems to warrant a deeper development at a number of other points of former important production in this extensive district.
>
> Other rich lead-ore strikes made in the Wood River belt were at the Carboniferous and Black Barb mines, on Kelly Gulch, and the Silver Fortune mine, on the east fork of Wood River.

Antelope district.—A lead oxidized ore and a siliceous silver ore came from this region near Darlington.

Dome district.—This region near Arco, Idaho, is divided by the county line. The Great Western mine in Blaine County produced some lead ore.

Hamilton district.—From the Badger Creek property, near Clyde, Idaho, several shipments of lead carbonate were made.

Lava Creek district.—The St. Louis property, near Martin, made a shipment of sulphide lead ore containing silver.

Little Smoky district.—The Blue Bird, formerly the Cannon Ball, made some tests on ore by amalgamation and concentration and shipped some bullion and lead concentrates.

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 613, 1915.
[2] Bell, R. N., Mining in Idaho: Eng. and Min. Jour., Jan. 22, 1916, p. 178.

Little Wood River district.—A shipment of lead ore was made by the Falls Mining Co.

Mineral Hill district.—Eleven deep mines produced 5,582 tons of ore, $4,533 in gold, 36,913 ounces of silver, 2,080 pounds of copper, 511,266 pounds of lead, and 352,324 pounds of zinc (spelter), valued at $91,329, or $16.36 per ton. This was a small increase over the production of 1914, when 23 deep mines produced 3,910 tons of ore, valued in all at $63,161. Of the total ore, 5,199 tons were concentrated, 361 tons were shipped to the spelter, and 22 tons were milled. Only small shipments were made from most of the mines; the Minnie Moore and Nay Aug were the two producers of importance. At both properties ore was separated into lead and zinc products, and at the Nay Aug crude galena and sphalerite were also shipped. Other shippers were the Utah Bellevue, Narrow Gauge, Jay Gould, and Jewell Princess. Probably the most important development was made on the North Star Triumph group, where a deposit of 100,000 tons of ore containing silver, lead, and zinc is said to be opened.

Skeleton Creek district.—A 10-stamp mill using amalgamation and concentration was operated at the El Oro mine, near Soldier, Idaho, from the end of April to November 1, 1915. Both bullion and rich concentrate were marketed. The San Mateo, a new property in the district, also produced some bullion and rich crude ore.

Vienna district.—The Vienna group, consisting of the Web Foot, Solice, Emma, and Lion claims, produced a shipment of lead ore containing considerable gold and silver.

Warm Springs district.—Nine deep mines produced 3,607 tons of ore, $6,740 in gold, 36,619 ounces of silver, 843 pounds of copper, 374,070 pounds of lead, and 89,412 pounds of zinc, valued at $54,122. This is an increase over the output of 1914, when the mines produced metals valued at $35,899. As in former years, the Independence mine was the main producer. Lead ore containing gold and silver was treated in the 80-ton concentration mill. The Homestake mine and the West Fork property also produced a good grade of lead ore. Zinc ore was shipped by the Boston-Idaho Co., near Ketchum. The Pulaski or Starlight & Noonday property treated gold ore by amalgamation and concentration, and also shipped directly a high-grade ore containing gold.

BOISE COUNTY.

Mine production in Boise County, Idaho, in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	60	17,067	$601,227	13,441	80	2,187	$608,756
1915	49	18,408	555,125	10,986	3,205	8,892	561,674
Increase or decrease, 1915	.....	+1,341	−46,102	−2,455	+3,125	+6,705	−47,082

[a] Includes placer production.

Fifteen deep mines produced 18,408 tons of ore, containing $171,866 in gold, 6,423 ounces of silver, 3,205 pounds of copper, and 8,892

pounds of lead, valued in all at $176,102, or $9.57 per ton. Of this ore, 18,311 tons were treated by amalgamation or cyanidation and 97 tons were shipped to various smelters. Bullion from the mills contained $161,311 in gold and 2,353 ounces of silver. With the exception of 27 tons of copper ore, all of the ore was siliceous. This county was the source of over 65 per cent of the placer gold of the State. In 1915 there were 34 placer operators producing gold valued at $383,259 and 4,563 ounces of silver. It is also the principal producer of gold from dredge operations in the State. The geology [1] of this region was described in 1898.

The production of gold and silver in this county from 1863 to the end of 1915 was $51,414,793 in gold and 2,103,927 ounces of silver, at a total value of $53,657,690. There was also some copper and lead, which is not included. The table giving this production by years appeared in the report [2] for 1914.

Banner district.—Some placer gold was produced from the Blue Bird mine on Edna Creek.

Boise Basin district.—Fifteen deep mines and 25 placers produced 18,408 tons of ore, $553,467 in gold, 10,963 ounces of silver, 3,205 pounds of copper, and 8,892 pounds of lead, in all valued at $560,005, a slight decrease from the output of 1914, when 9 deep mines and 36 placers produced $600,746. Nearly all of the ore, or 18,311 tons, was milled and produced bullion containing 7,803.42 ounces of gold and 2,353 ounces of silver, as well as 120 tons of concentrates containing considerable gold. The district produced placer gold valued at $381,601 and 4,540 ounces of silver, valued at $383,903. The Boston-Idaho Gold Dredging Co. was, as in former years, the largest producer of placer gold, and treated nearly 3,500,000 cubic yards of gravel during 10 months of the year. There was some decrease from the output of 1914, as most of the best ground of the company is said to have been worked. Other important placers of the district were the Clay Gulch, Coyote, Crevice Diggings, Native Missourian, Leary & Brogan, and Gold Hill. The largest output of bullion from deep mines was won from the Gold Hill & Iowa property by a 50-ton plant using amalgamation and concentration. The property is opened to a vertical depth of 500 feet. During the year 1,500 feet of work was done. This property and others in the district are fully described in a recent report.[3] The National M. & D. Co., operating the Mountain Chief mine, was next in importance, and operated a 25-ton plant using amalgamation and concentration. Rich concentrates and crude ore were also shipped. The ore has a value of approximately $25 a ton. The Golden Age mine again became an important producer of bullion through the operation of a 15-stamp mill equipped with concentration tables. Concentrates, however, were not marketed. Considerable work was done at various properties in the district, including the Ingle group and the Coon Dog group, by the Diana Mines Co. Development is said to have opened important bodies of copper sulphide and lead sulphide ore. Some bullion, crude ore, and concentrates were marketed.

[1] Lindgren, Waldemar, The mining districts of Idaho Basin and Boise Ridge, Idaho: U. S. Geol. Survey Eighteenth Ann. Rept., pt. 3, pp. 625–736, 1898.
[2] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 616, 1915.
[3] Jones, E. L., jr., Lode mining in the Quartzburg and Grimes Pass porphyry belt, Boise Basin, Idaho: U. S. Geol. Survey Bull. 640, pp. 83–111, 1916 (Bull. 640–E).

Payette River district.—Some placer gold came from various points along Payette River, near Banks, Cascade, and Fruitland. The Grooms and Milwaukee placers were the principal mines. Four operators produced $819 in gold and 13 ounces of silver.

Unorganized or Boise River district.—Three placers produced $519 in gold and 5 ounces of silver. The principal operation was at the Golden Terror property.

West View district.—This district, formerly in Boise County, has been included in the newly organized Gem County.

BONNER COUNTY.

Seven deep mines and 2 placers produced 651 tons of ore containing $708 in gold, 13,651 ounces of silver, 9,723 pounds of copper, and 165,735 pounds of lead, valued in all at $17,119, against $13,253 in 1914. The ore produced at 7 mines had a total value per ton of $26.01 and a gold and silver value per ton of $11.43. Most of the ore, or 468 tons, was lead ore, 158 tons was siliceous ore, and 25 tons was copper ore. Of the total quantity 457 tons were concentrated, making 110 tons of concentrates valued at $8,428, or $76.62 per ton, and 194 tons represented crude ores shipped to smelters, valued at $8,504, or $43.84 per ton. In 1915 the northern part of what was formerly Bonner County, including part of the Priest Lake district, was made into Boundary County.

Lakeview district.—The Comet claim and the Conjecture mine, of the Pittsburg Mining Co., made small shipments of galena.

Moyie Yahk district.—Some placer gold was shipped from the property of the Moyie Hydraulic M. & P. Co.

Pend Oreille district.—Five deep mines produced 640 tons of ore, containing $512 in gold, 12,469 ounces of silver, 9,723 pounds of copper, and 163.308 pounds of lead, valued in all at $16,210, or $25.33 per ton. In 1914 four mines produced metals valued at $7,951. At the Lawrence mine, near Clark Fork, a 50-ton concentrator was operated for a short period and produced an exceptionally high-grade lead concentrate. The B. F. & H. mine, the Katherine mine, and the Keystone property produced silver ore, and one shipment of oxidized copper ore was made from the Green Monarch property.

BONNEVILLE COUNTY.

Mount Pisgah district.—Production from 4 placers and one deep mine amounted to $4,532 in gold, 39 ounces of silver, and 824 pounds of copper. The American Placer, the Barnes group, and the Midas claim, near Gray, were operated by the hydraulic method, and the Mount Pisgah and Caribou property produced a small shipment of copper ore.

BOUNDARY COUNTY.

This county was established from the northern portion of what was Bonner County. It borders the Dominion of Canada and takes in only the part of the Priest Lake district lying north of the lake.

Priest Lake district.—The Idaho-Continental mine, 26 miles west of Porthill, produced considerable lead sulphide of shipping grade and also milled a greatly increased quantity of ore that made a

good grade of concentrate. Caterpillar tractors were used to haul ore and concentrates from the mine to the railway. The mill, equipped to treat 250 tons per day, was destroyed by fire July 30. The plant was, therefore, only operated for two months in 1915, but development was continued, and the construction of a new plant was begun immediately and will be in operation in the middle of 1916. This is one of the important lead mines of the State, aside from those of Lemhi and Shoshone counties.

CANYON COUNTY.

Four small placers produced $378 in gold and 5 ounces of silver. Claims near Parma and Notus produced some gold from Boise River and properties near Payette from Snake River.

CASSIA COUNTY.

Three deep mines produced 141 tons of ore, valued at $7,676, or $54.44 per ton. The Melcher & Cumora property, in the Stokes district, shipped a good grade of lead ore containing gold, silver, and copper. From the Deer Ridge group, a new discovery in Black Pine district, a few shipments of zinc carbonate were made. An oxidized lead ore was shipped from the Hazel Pine mine in an unorganized district north of Kelton, Utah.

CLEARWATER COUNTY.

Eighteen properties, only one of which was a deep mine, produced gold valued at $28,156 and 387 ounces of silver. The output in 1914 was valued at $18,948. The increase in 1915 was due to the operations of the dredge by the Pierce Co. (Ltd.)

Burnt Creek district.—Five small placers produced $329 in gold and 3 ounces of silver. The Grubstake was the most important producer.

Moose Creek district.—Some placer gold was taken from the Independence and Midas properties near Moose City.

Pierce district.—Ten placers and 1 deep mine produced 15 tons of ore—$27,759 in gold and 384 ounces of silver, valued at $27,954. By reason of a shortage of water for power, the 3½ cubic foot dredge of the Pierce Co. was operated only six months, but made important shipments of bullion. The dredge of the American Placer Mining Co. was started, but needs some changes before it will be operated continuously. The Wild Rose group, a lode property, is said to have opened $10 ore by means of a 1,250-foot tunnel.

CUSTER COUNTY.

Fourteen deep mines produced 54,804 tons of ore, an increase of 33,014 tons. The output of the county, including gold and silver from seven placers, was $84,796 in gold, 142,601 ounces of silver, 4,767,025 pounds of copper, and 42,786 pounds of lead, valued at $993,335, or an average per ton of $18.11 for the four metals and of $2.85 per ton in gold and silver. With the exception of 42 tons of siliceous ore and 91 tons of lead ore, the entire product was copper ore. Practically all the ore, or 54,790 tons, was shipped to smelters.

Only 14 tons were treated at gold and silver mills, the bullion having a total value of $184. The important mineral area of the county[1] was described in 1913.

Alder Creek district.—Four deep mines produced 54,435 tons of ore, containing $65,252 in gold, 125,574 ounces of silver, 4,712,649 pounds of copper, and 21,393 pounds of lead, valued in all at $954,636, or an average value per ton of $17.54. An oxidized copper ore came from the Copper Basin mine and carbonate lead ore from the Homestake & Copper Queen, but the main production, as in former years, was from the White Knob mine of the Empire Copper Co. The mine was operated the entire year and every effort was made, especially toward the close of the year, to take advantage of the increased price of copper. This mine was responsible for upholding the copper production of the State, as that from the Snow Storm mine, in Shoshone County, was very small. Lessees shipped as much as 9,000 tons a month for several months, but averaged less than 5,000 tons a month for the year. A greater quantity could have been shipped if the smelters could receive it. The company has 37 claims, and the deposit is opened to the 900-foot level. A lower tunnel 4,500 feet long is being driven to gain an additional depth of 900 feet.

Bayhorse district.—Four deep mines produced 54 tons of ore, $4 in gold, 7,979 ounces of silver, 4,920 pounds of copper, and 21,393 pounds of lead, valued in all at $5,916, or $109.55 per ton. This was $18,479 less than in 1914. The plant of the Red Bird Smelting Co. was idle, and comparatively few shipments of lead ore were made from the other mines. Small shipments of copper ore came from the Dryden and Ramshorn properties.

Loon Creek district.—Shipments consisted of some placer gold taken out by the Loon Creek Hydraulic Mining Co. and some matte, rich in gold, silver, and copper, from the Lost Packer mine. A 50-ton flotation plant, designed to treat low-grade dump ore, of which there is said to be over 20,000 tons, averaging $20 per ton, was under construction.

Stanley Basin district.—Three small placers produced $261 in gold and 5 ounces of silver. The production in 1914 was $2,881 in gold and 68 ounces of silver. The district output has been steadily decreasing for the last five years.

Yankee Fork district.—Five deep mines and three placers produced 42 tons of ore—$9,135 in gold, 7,382 ounces of silver—valued at $12,878. This was $18,776 less than in 1914. Some ore, exceptionally rich in gold and silver, was shipped from the old Montana mine, operated by the Custer Slide Mining & Development Co. The ore was produced and shipped in 1915 but did not reach the smelter until 1916. The ore contained from 8 to 23 ounces of gold and from 53 to over 1,000 ounces of silver per ton. The Rough Creek was the only important placer that was productive.

ELMORE COUNTY.

Eleven deep mines produced 15,499 tons of ore, or 12,260 tons more than was produced by 8 operators in 1914. The average per

[1] Umpleby, J. B., Some ore deposits of northwestern Custer County, Idaho: U. S. Geol. Survey Bull. 539, 1913.

ton in gold and silver was $4.74, against $3.40 in 1914. The total output of the county, including that of 13 placers, was $77,114 in gold and 6,195 ounces of silver, valued in all at $80,255. The placer output amounted to $6,687 in gold and 87 ounces of silver. During the year work was resumed at several of the old producers, which accounts for the important increase. All of the ore was siliceous, and all but 51 tons was treated in gold and silver mills.

Bear Creek district.—One deep mine and 3 placers produced 5 tons of ore—$4,083 in gold and 68 ounces of silver—valued at $4,117. The Feather River property of the Elmore Placer Mining Co. was the only important placer producer in the district. Some bullion was secured from the Overland and Tip Top property.

Black Warrior district.—Three deep mines produced 1,310 tons of ore—containing $15,021 in gold and 252 ounces of silver—valued at $15,149. Considerable bullion came from the Overlook mine, where a small 3-stamp mill using amalgamation was in operation from July to December.

Highland district.—This district, near Twin Springs, produced some placer gold from the Last Chance claim.

Middle Boise district.—Two deep mines and 3 placers produced 12,686 tons of ore, $48,954 in gold, 2,919 ounces of silver, valued at $50,434. Placer gold came from the Boise King group and the Idaho Bonanza property. The most important deep mine output was that of the General Pettit mine, operated by the Boise Rochester Mining Co. Although work was restricted by lack of power and water, the milling plant using amalgamation was operated for about half the year. Concentrates were made but not marketed. Ore was also treated by amalgamation and concentrates by cyanidation at the Atlanta mines. The mine was not operated; the material treated consisted entirely of old dumps. The plant has 5 Huntington mills, rolls, and concentration tables, giving a capacity of 150 tons per day.

Neal district.—The Homestake mine produced bullion from the operation of a cyanide mill. Results were meager compared with former productions.

Snake River district.—The Edna mine, 3 miles south of King Hill, produced placer bullion having a fineness of 0.954.

Twin Springs district.—Four small placer operators produced $515 in gold and 6 ounces of silver, against $1,275 in gold and 16 ounces of silver in 1914.

Volcano district.—The Bowerman group, near Hill City, near the line of Blaine County, made a shipment of silver ore containing some gold.

FREMONT COUNTY.

The property of the Wilbert Mining Co., in the Dome district in Fremont County, produced considerable crude lead ore and concentrates, principally the latter, and paid an initial dividend of $10,000. The mine is equipped with a 100-ton concentration plant, which was operated the latter part of the year, when about 500 tons of ore and concentrate per month were shipped. A sample of concentrates ran 5.8 ounces of silver and 55.85 per cent lead, and a lot of crude ore

averaged 6.55 ounces of silver and 49.5 per cent lead. At the close of the fiscal year the company [1] reported as follows:

The high price of lead allowed of a good deal of poor ore being extracted, also small streaks and shoots that would not pay otherwise. From No. 5 level to the surface the main shoot is nearly all stoped. The mill treated 15,204 tons, assaying 25 per cent lead and 3.86 ounces silver. Concentrate produced was 5,787 tons, averaging 52.06 per cent and 8.02 ounces, equal to 6,025,600 pounds lead and 46,419 ounces silver. The cost was $3.56 per ton.

The deposit was described by Umpleby in 1914.[2]

GEM COUNTY.

The southwestern part of Boise County and the eastern part of Canyon County were combined in 1915 to make the newly organized Gem County. It includes the West View district, formerly in Boise County. Two deep mines and 2 placers produced 62 tons of ore, $2,727 in gold, 2,686 ounces of silver, and 1,748 pounds of lead, valued at $4,171. The output was valued at $5,242 in 1914. The Dewey group produced siliceous gold ore containing considerable silver and a little lead, and the Nellie Bloom produced a good grade of gold ore.

GOODING COUNTY.

Snake River district.—Four small placer mines produced $908 in gold and 2 ounces of silver. The Big Body placer, near Clearlake, was the principal producer.

IDAHO COUNTY.

Mine production in Idaho County, Idaho, in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	97	4,319	$43,717	1,084	6,457	.....	$45,174
1915	85	4,155	97,196	3,262	1,284	11,401	99,611
Increase or decrease, 1915	.....	−164	+53.479	+2,178	−5,173	+11,401	+54,437

[a] Includes placer production.

Thirty-two deep mines in 1915 produced 4,155 tons of ore, a decrease of 164 tons. The ore had a total value per ton of $17.17 and of $16.98 in gold and silver. This was an increase from the value of the ore in 1914, which was $5.73 and $5.53, respectively. The total output of the county, including that of 53 placers, was $97,196 in gold, 3,262 ounces of silver, 1,284 pounds of copper, and 11,401 pounds of lead, valued at $99,611. The placer output was $28,131 in gold and 292 ounces of silver. All the ore, with the exception of 22 tons of lead ore, was siliceous, and 4,097 tons of it was treated at gold and silver mills, and 58 tons were shipped to smelters.

[1] Wilbert Mining Co. Ann. Rept. for year ending May 1, 1916.
[2] Umpleby, J. B., Lead-silver deposits of the Dome district, Idaho: U. S. Geol. Survey Bull. 540, pp. 212–222, 1914.

Camp Howard district.—Small placer operations near Whitebird resulted in the production of $843 in gold and 6 ounces of silver.

Clearwater district.—There was a small placer production and an output of gold ore of good grade from the Dewey group.

Dixie district.—Four deep mines and 2 placers produced 39 tons of ore, containing $2,106 in gold and 28 ounces of silver, valued at $2,120. The Free Gold deep mine was the principal producer.

Elk City district.—Six deep mines and 8 placers produced 1,015 tons of ore, containing $24,467 in gold, 288 ounces of silver, and 17 pounds of lead, valued at $24,614, against $14,564 in 1914. The placer output was $7,084 in gold and 54 ounces of silver. Most of the placer production came from claims on American River, operated by the Elk City Gold Dredging Co. The old plant was being remodeled and was only operated about 90 days during the year. Some bullion came from the Gem, Grangeville, Gold Rock, and Mascot mines, but the important shipments of bullion came from the Mineral Zone property, which made a considerable production from the operations of a 3-stamp mill equipped for amalgamation. Much ore was said to be opened at the South Fork mine, formerly a good producer.

Florence district.—One deep mine and 4 placers produced $881 in gold and 18 ounces of silver. The principal operations were at the Florence and Buttercup groups.

Maggie Creek district.—One deep mine and 3 placers produced 25 tons of ore, $536 in gold and 46 ounces of silver. In addition to the yield from small placers, bullion and concentrate were shipped from the Syrinda mine, near Kooskia.

Marshall Lake district.—The Three Mile placer, near Resort, was the only productive placer of importance.

Mount Idaho district.—Some gold was obtained by amalgamation from the Joe Pfeufer mine, a new property not far from Grangeville.

Newsome district.—One deep mine and three placer operators produced 3 tons of ore, $1,035 in gold, and 11 ounces of silver. The placer product came largely from the Moose Creek ground and the Old Montana property.

Orogrande district.—Six unimportant deep mines and 1 placer produced 50 tons of ore—$1,250 in gold, and 20 ounces of silver, valued at $1,260—against $5,072 in 1914. The output came from the Syringa, Iola, Coeur d'Alene, and Center Star properties. The Butte & Orogrande produced in 1914, but made no shipments in 1915. It is planned to remodel the mill entirely.

Profile district.—From the Red Metal mine a small shipment of siliceous silver ore was made. The Sunrise property made a shipment of lead ore.

Robbins district.—Some bullion was won by cyanidation from the Jumbo mine, formerly an important producer.

Salmon River district.—Some gold was taken from the bank of Salmon River near Greer, Idaho.

Simpson district.—Nine placers produced $2,737 in gold and 16 ounces of silver—valued at $2,745. The most important production came from the Jim Crow placer, operated by drift mining. Other producers were the Dandy, Gold Nugget, Lime Point, Old Channel, and Spring Bar.

Ten Mile district.—Five placers and 5 deep mines produced 486 tons of ore—$11,268 in gold and 179 ounces of silver—valued at $11,358. The larger part of the production came from the New York mine, both bullion and concentrates being shipped. Other producers were the Gold Hill, Wonder, and Equator. A 5-stamp Chilean mill was erected on the last-named property. The productive placers were the Crescent, Alpine Bar, Tippie, and Phoenix.

Thunder Mountain district.—On Rush Creek, near Thunder Mountain, the decomposed quartz from the Dewey mine was worked by sluicing and some bullion was shipped.

Warren district.—Three deep mines and 10 placers produced 2,347 tons of ore—$45,248 in gold and 807 ounces of silver—valued at $45,657. The placer production was $8,042 in gold and 70 ounces of silver. The principal part of the placer production came from the hydraulic mines—Golden Rule, Gold Dollar, Lucky Strike, and Buck Diggings. Nearly all the deep mine bullion came from the Standard mine, where the ore was treated by amalgamation. A large part of the work done at the property, however, was that of development.

KOOTENAI COUNTY.

The southern part of what was formerly Kootenai County, which included the Tyson district, has been formed into Benewah County. That part still known as Kootenai County did not produce in 1915.

LATAH COUNTY.

Three placer properties produced $659 in gold and 4 ounces of silver in the Hoodoo district, near Harvard, and in the Gold Creek district, near Potlatch.

LEMHI COUNTY.

Mine production in Lemhi County, Idaho, in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	32	17,550	$305,991	71,218	35,300	2,810,722	$459,687
1915	49	25,560	182,259	207,436	179,183	8,791,046	731,965
Increase or decrease, 1915	.....	+8,010	−123,732	+136,218	+143,883	+5,980,324	+272,278

[a] Includes placer production.

Thirty-seven deep mines produced 25,560 tons of ore, an increase of 8,010 tons more than the production of 1914, when only 18 deep mines were operated. The average value of the ore increased from $17.16 per ton in 1914 to $24 in 1915. The value per ton in gold and silver decreased from $10.64 to $6.61. Twelve placer mines produced $118,123 in gold and 449 ounces of silver, including recoveries from the operation of two dredges. Of the total tonnage, 16,236 tons were crude ore shipped to smelters, only 623 tons were concentrated and 8,701 tons were treated in gold and silver mills. Crude

ore had a total value of $550,653, or $33.92 per ton; concentrates, $20,432, or $163.45 per ton. Separated according to different kinds of ore, the largest part of the ore, or 15,496 tons, was lead ore; 9,328 tons, siliceous ore; 734 tons, copper ore; and only 2 tons, copper-lead ore. The geology of the region and estimates of the past production of many of the districts were published in 1913.[1]

Blackbird district.—The Ludwig mine, of the Musgrove Mining Co., was operated the greater part of the year, and the cyanide mill, which produced considerable bullion, was active from April until August.

Blue Wing district.—A small shipment of sulphide copper ore was made from the Castle Rock property.

Carmen Creek district.—A few tons of old copper concentrates were shipped from the Kinney group.

Eldorado district.—Three deep mines and 2 placers produced 37 tons of ore, $14,963 in gold, 324 ounces of silver, and 5,301 pounds of copper, valued at $16,055. The principal operations were those of the Bohannon Dredging Co., operating its 6-foot bucket dredge, 14 miles from Salmon. The plant was only operated from the first of April to the first of October. Over 500,000 cubic yards of material was handled during the year. The gold averages about 0.900 fine.

Eureka district.—Three deep mines and 2 placers produced 1,789 tons of ore, $4,893 in gold, and 42 ounces of silver, valued at $4,915, against $1,970 in 1914. The Mullen dredge was not operated during the year. A small placer production came from the Hawkeye property. Most of the gold was taken from the Queen mine, where a trial run of the mill was made on dump ore to sample the property. At the Gravel Range property ore was treated by amalgamation and cyanidation. Four cyanide tanks were added during the year, and the plant was operated during August.

Gibbonsville district.—Six deep mines and 3 placers produced 257 tons of ore, $4,863 in gold, and 36 ounces of silver, valued at $4,881. The principal placer operations were on Hughes Creek, 7 miles from Gibbonsville. The deep mine bullion came from the Governor, Clara Morris, and Gibbonsville groups.

Indian Creek district.—The Kittie Burton & Ulysses property was operated throughout the year by lessees. When sufficient ore was accumulated, the plant, equipped with 15 stamps and amalgamation, was operated. The production, however, was considerably less than in former years.

Kirtley Creek district.—Production consisted of some ore amalgamated at the White Horse group and bullion shipments from the dredge operations on the Kirtley Creek property. The plant was operated the entire year and treated an average of 100,000 cubic yards a month. Aside from the work of the Boston-Idaho Co., in Boise Basin, this is the most important dredge operation in the State.

Mackinaw district.—One deep mine and 3 placers produced 1,500 tons of ore, $2,384 in gold, and 15 ounces of silver, valued at $2,392. The Richardson and Hockensmith placers were productive,

[1] Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, 1913.

and the old Italian mine, owned by the Leesburg Mining & Power Co., produced bullion by amalgamation. The mine was operated by lessees in 1915.

McDevitt district.—The Copper Queen, near Tendoy, shipped both crude copper ore and concentrates containing considerable gold.

Mineral Hill district.—Seven deep mines and 1 placer produced 160 tons of ore, $2,569 in gold, and 49 ounces of silver, valued at $2,594. Some ore was treated from the Sheep Creek, Speculation, Merry Widow, Kismet, and Clipper Bullion mines.

Texas district.—Five deep mines produced 16,041 tons of ore, $16,310 in gold, 203,837 ounces of silver, 79,546 pounds of copper, and 8,714,280 pounds of lead, valued at $543,146, or $33.86 a ton. This approached normal figures and was considerably more than the output of 1914, when 10,165 tons of ore had a value of $233,975. All the ore, principally oxidized lead ore, was a first-class product shipped to various smelters. The largest shipper was the Pittsburg-Idaho Co., which averaged about 1,000 tons a month, ranging from 800 in January to 1,500 in August. In 1912 this same property shipped about 2,000 tons a month. Ore containing 10 to 15 ounces of silver per ton and 30 per cent lead was mined by lessees from the 400, 500, and 600 foot levels. The Latest Out was also an important producer, having average shipments of approximately 400 tons a month. From the Gilmore property a few shipments of oxidized lead ore and also of iron ore containing gold and silver were made.

Unorganized district.—Four properties produced 221 tons of ore, $2,343 in gold, 713 ounces of silver, 301 pounds of copper, and 76,766 pounds of lead, valued at $6,365. This output includes a small quantity of ore amalgamated at the Parker mine and at the Ed Williams group on Parker Mountain, and some oxidized lead ore shipped from the Cabin claim near Nicholia.

MINIDOKA COUNTY.

Some placer gold was taken from Snake River, near Rupert.

NEZ PERCE COUNTY.

The Homestead Entry placer mine, in Clearwater district, produced gold by drifting, and the Gold Standard property, in Cave Gulch district, made tests on ore by amalgamation.

OWYHEE COUNTY.

Mine production in Owyhee County, Idaho, in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	
1914	19	1,641	$17,792	10,952	66	$23,851
1915	18	732	51,206	36,452	.....	69,687
Increase or decrease, 1915	.....	−909	+33,414	+25,500	−66	+45,836

[a] Includes placer production.

Fourteen deep mines produced 732 tons of ore, a decrease of 909 tons from the output of 1914 and a decided decrease from the output of former years. The ore had an average value per ton in gold and silver of $94.82. The total output of the county, including that of 4 placers, had a value of $51,206 in gold and 36,452 ounces of silver, or a total value of $69,687. In 1912 the county produced metals valued at $417,967, and considerably over a million dollars a year in many of the former years. The production of gold and silver in this county from 1863 to 1914 was given in the report for 1914.[1] The production of gold and silver alone, from the discovery of gold in 1863 to and including 1915, was $21,620,514 in gold and 24,334,181 ounces of silver, having a total value of $40,366,201. The entire output of 1915 was siliceous ore, of which 56 tons were shipped to smelters and 676 tons were treated by amalgamation or cyanidation, principally the latter. Four placers produced $254 in gold and 42 ounces of silver, having a total value of $275.

Carson district.—Twelve deep mines and 1 placer produced 599 tons of ore, $50,374 in gold, 35,568 ounces of silver, valued at $68,407. The Trade Dollar mine was not operated by the company, but the greater part of the production came from a lease on part of this property. The De Lamar mine was closed indefinitely, and only a very small production was made. The Silver City Mining & Milling Co. produced bullion through the operations of a 25-ton plant using the all-sliming process. The mill formerly used amalgamation. There were several other small producers, including the Bergh, Banner, Burro, and Pauper group.

Castle Creek district.—During May and June a small quantity of ore was treated in the 3-stamp plant using cyanidation at the property of the Castle Falls Mining Co.

French district.—A few tons of ore were milled from the Tango claim, where considerable development and prospecting was done. A 5-stamp amalgamation mill was used.

Snake River district.—Three placers produced $197 in gold and 2 ounces of silver, from bench gravel not far from Murphy, Idaho.

POWER COUNTY.

Three placers on Snake River, near Neeley and American Falls, produced $700 in gold and 2 ounces of silver. A small prospecting dredge using the revolving screen and burlap tables was operated at the Diamond claim.

SHOSHONE COUNTY.

Mine production in Shoshone County, Idaho, in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	38	2,152,268	$64,157	12,178,194	4,242,662	339,698,426	41,523,383	$22,728,903
1915	52	2,255,475	46,433	11,158,955	1,941,296	328,398,594	69,685,003	30,119,424
Increase or decrease, 1915	.....	+103,207	−17,724	−1,019,239	−2,301,366	−11,299,832	+28,161,620	+7,390,521

[a] Includes placer production.

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 626, 1915.

This county includes the Coeur d'Alene region, the most important mining center of the State. The region includes several mining districts, the production of which is given below. In July, 1915, there are said to have been 5,000 men employed in the mines. Forty-three deep mines in the county produced 2,255,475 tons of ore, an increase of 103,207 tons. The number of deep mines in 1914 was 29. The ore mined had a value per ton in gold and silver of $2.53. The production of zinc and the increased prices of metals increased the total value per ton of the ore from $10.56 in 1914 to $13.35 in 1915. The value of the county output increased nearly 33 per cent and represented more than 90 per cent of the total value of the State output. There was a small increase in ore sold or treated, and the production of zinc was much larger, but the output of the other metals was considerably smaller. The closing of the Snow Storm mine naturally affected the output of copper, and the temporary idleness of one of the big lead mines materially reduced the production of lead and silver. The ore was largely lead ore and lead-zinc ore, 1,616,330 tons of the former and 508,326 tons of the latter. There were also 111,555 tons of zinc ore, 19,264 tons of copper ore, and 400 tons of siliceous ore sold or treated. Ninety-six per cent or 2,156,046 tons of crude ore, including 3,860 tons of old tailings, were concentrated and produced 329,530 tons of concentrates, containing $29,304 in gold, 8,431,322 ounces of silver, 1,446,712 pounds of copper, 257,855,890 pounds of lead, and 60,727,218 pounds of zinc (spelter), having a total value of $24,206,561, or $73.46 per ton. These concentrates were composed of 1,482 tons of copper concentrates, containing 18.23 ounces of gold, 31,233 ounces of silver, and 484,509 pounds of copper; 249,312 tons of lead concentrates, containing 1,393.34 ounces of gold, 8,124,688 ounces of silver, 962,203 pounds of copper, and 252,004,522 pounds of lead; 69,093 tons of zinc concentrates, containing 143,504 ounces of silver, 4,170,076 pounds of lead, and 53,726,994 pounds of zinc; 9,640 tons of lead-zinc concentrates, containing 131,895 ounces of silver, 1,681,292 pounds of lead, and 7,000,224 pounds of zinc; and 3 tons of siliceous concentrates, containing 6 ounces of gold and 2 ounces of silver. There were 400 tons of ore treated in gold and silver mills. In 1915 the county had 25 milling plants having a combined daily capacity of 9,200 tons, many of which were active full time. First-class crude ore shipped to smelters amounted to 95,169 tons and contained $12,798 in gold, 2,727,579 ounces of silver, 494,584 pounds of copper, 70,542,704 pounds of lead, and 8,957,785 pounds of zinc (spelter), valued at $5,908,504, or $62.08 per ton. The crude ore smelted included 837 tons of copper ore, containing 45.43 ounces of gold, 3,689 ounces of silver, and 90,989 pounds of copper; 83,463 tons of lead ore, containing 573.66 ounces of gold, 2,695,198 ounces of silver, 403,595 pounds of copper, and 69,880,170 pounds of lead; 10,395 tons of zinc ore, containing 614,760 pounds of lead and 8,595,554 pounds of zinc (spelter); and 474 tons of lead-zinc ore, containing 6,900 ounces of silver, 47,774 pounds of lead, and 362,231 pounds of zinc (spelter). The placer production in the county by 9 operators was $1,866 in gold and 15 ounces in silver,

valued at $1,874. Several articles[1] recently published contain notes of interest on the county.

Mine production in the Coeur d'Alene region, Shoshone County, Idaho, 1884–1915.

Year.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Fine ounces.	*Pounds.*	*Tons.*	*Pounds.*	
1914	$64,157	12,178,194	4,242,662	169,849	41,523,383	$22,728,903
1915	46,433	11,158,955	1,941,296	164,199	69,685,003	30,119,424
1884–1915	5,476,257	142,222,795	62,806,908	2,283,256	170,688,937	315,456,316

Since the beginning of mining in 1884, the Coeur d'Alene region has produced gold, silver, copper, lead, and zinc valued at $315,456,316—gold, $5,476,257; silver, $85,502,478; copper, $9,566,895; lead, $200,615,491; and zinc (spelter), $14,295,195. The production of this region by years, from 1884 to 1913, is given in the report for 1913.[2] From 1904 to 1915 operators in the region mined, shipped, or treated 21,672,103 tons of ore.

Beaver district.—Four deep mines and 3 placers produced 115,892 tons of ore, $997 in gold, 215,325 ounces of silver, 1,491 pounds of copper, 8,275,302 pounds of lead, and 45,251,422 pounds of zinc (spelter), valued at $6,110,543, or an average value per ton for the ore of $52.72. The total value was $4,793,361 more than in 1914, an increase largely due to the output of the Consolidated Interstate Callahan property, which is credited to this district, though partly in the Placer Center district. The district produced only $720 in gold and 9 ounces of silver from placers near Delta. A few shipments of lead concentrates were made from the Idora mine, which was operated for a short time. The Tuscumbia was under lease to the Tuscumbia Leasing Co., which used the Idora mill, and made many shipments of a good grade of lead concentrate the last half of the year. Both the mine and the mill of the Consolidated Interstate & Callahan Mining Co. were active throughout the year, and the property became noted as the largest zinc producer and dividend payer of the State. The quarterly printed statements of this company have been combined to obtain the following data for 1915: There were 113,795 tons of ore mined, of which 99,545 tons were milled. The shipping products were 510 tons of lead ore, 9,396 tons of zinc ore, 3,330 tons of lead concentrate, and 45,317 tons of zinc concentrate. The lead ore and concentrate contained 90,033 ounces of silver and 4,176,843 pounds of lead, averaging 23.45 ounces of silver per ton of crude ore and concentrate and 54.39 per cent lead. The zinc ore and concentrate, both sulphide, contained 53,208,175 pounds, gross, of zinc, or 45,226,949 pounds calculated as recoverable spelter. The average assay for the year for both products was 48.62 per cent, gross, zinc. The recovery

[1] Huston, George, Copper beds of the Cœur d'Alene: Min. and Sci. Press, Jan. 23, 1915, p. 145. Megraw, H. A., Metallurgy of the Cœur d'Alenes: Eng. and Min. Jour., Nov. 20, 1915, p. 827. Ellis, H. I., New developments in the Cœur d'Alenes: Eng. and Min. Jour., Aug. 28, 1915, p. 337; Lead smelting projects in the Cœur d'Alene: Eng. and Min. Jour., Nov. 6, 1915, p. 751. Ingalls, H. W., Idaho in 1915: Min. and Eng. World, Feb. 5, 1915, p. 304. Bell, R. N., Seventeenth Ann. Rept. mining industry of Idaho, for 1915.

[2] U. S. Geol. Survey Mineral Resources, 1913, pt. 1, 780, 1914.

in the last quarter of the year was 82 per cent. In September the new aerial tramway from the mill to Sunset was complete. According to the statement to the county assessor, the quantity of ore extracted was 113,795 tons, which had a gross value of $4,540,671. Cost of extraction was $849,241; freight and treatment, $643,863; betterment and repairs, $126,079; and net profit, $2,921,488. Dividends declared in 1915 amounted to $2,557,445, the initial one being paid in April. According to the annual printed report:[1]

It was the aim of the management to develop sufficient ore reserves to insure steady operations for a period of three to four years, and thereafter to have this development keep pace with ore extraction. With this in view, the ore body, which hitherto had been opened up only on Interstate Tunnel No. 4, was developed on levels 2, 3, and 3½, and a shaft was sunk 475 feet from tunnel 4 and the ore body opened up on levels 5 and 6. The various levels were connected, and ore is now being extracted on four levels. The shaft is equipped with skip chutes, so that it can at short notice be placed in commission for hoisting our full requirements of ore from levels below tunnel No. 4 after our ore reserve above tunnel No. 4 is exhausted. At the present time only development work is being carried on below tunnel No. 4. All ore mined above this level is taken out through the Callahan raise, which is connected with levels 3 and 3½ and equipped with ore pockets.

A radical change was made in our stoping system. We abandoned the square-set system entirely, employing instead the so-called waste-fill system. This has not only materially reduced our mining cost, but it has also resulted in a material increase in the metal contents of our mill feed, which was increased from about 20 to 22 per cent zinc to 27 to 30 per cent zinc.

The quantity of ore developed above level No. 6 is sufficient to insure operations at the present rate of production for approximately four years. The property is now in shape to keep up development work with the idea of constantly replacing whatever quantity of ore is extracted in stoping for many years to come. * * *

A new and large modern air compressor was installed and connected with the workings through a new 8-inch pipe line.

At the Ray Jefferson, which joins the Interstate-Callahan on the west, a considerable body of lead-zinc ore was developed, and plans were made for a 250-ton mill. There is a possibility that a branch railroad connecting mines in this region with the Murray branch of the Oregon-Washington Railroad & Navigation Co. will be constructed.

Coeur d'Alene district.—This district, north of Murray, produced some placer gold as well as bullion and concentrates from the Friday property and the Winnie mine.

Eagle district.—Only a few ounces of gold came from the Mother lode and Eagle placers. The Eagle was formerly an important producer.

Evolution district.—A good production of lead sulphide ore, containing considerable silver, was shipped from the Yankee Boy mine. The property, however, was only operated during the first half of the year. The best ore shipped contained 250 ounces of silver and 25 per cent lead, with some copper and gold. Good progress was made with the 100-ton concentration plant erected at the H. E. M. group, near Osborne.

Hunter district.—Six deep mines produced 388,382 tons of ore, $10,966 in gold, 1,218,884 ounces of silver, 595,230 pounds of copper, 47,785,070 pounds of lead, and 4,111,854 pounds of zinc (spelter), valued at $3,488,873, or $8.98 per ton. This is an increase in value

[1] Consolidated Interstate-Callahan Mining Co. Third Ann. Rept., for year ending June 30, 1915.

of $942,172. Most of the ore, or 361,138 tons, was concentrated. and, with 100 tons of old tailings, made 42,021 tons of concentrates. The remainder of the ore, or 27,144 tons, was shipped directly to smelters. The Morning mine of the Federal Mining & Smelting Co. was shut down until April 12, but operated continuously thereafter. According to reports filed with the county assessor this mine produced 250,260 tons of ore, part of which was shipped and the remainder was milled in the 1,000-ton concentration plant, equipped with flotation machines. The gross value of the various products was $1,947,606; cost of extraction, $598,899; freight and treatment, $741,996; betterment and repairs, $35,151; and net profit, $571,560. The Federal Mining & Smelting Co.,[1] controlling the Morning mine in this district and other mines noted in other districts, furnishes the following data in its report for 1915:

There were mined at all of the properties 461,252 tons (wet weight) of ore, of which 29,371 tons were first class. There were milled 408,315 tons (dry weight) of ore, an average of 34,026 tons per month.

There were produced during the year 66,610 tons of lead concentrates and shipping ore averaging 40.20 per cent lead and 14.77 ounces silver per ton; 8,839 tons zinc shipping ore and concentrates averaging 42.46 per cent zinc. Of this amount 29,338 tons were first-class shipping lead ore, which carried from 22.95 per cent to 52.25 per cent lead and averaged 30.43 per cent.

The first class from Wardner averaged 45.73 per cent, and from Morning 28.87 per cent lead.

At Wardner the average silver content in concentrates decreased from 22.4 ounces in 1914 to 19.6 ounces in 1915, and the average lead content from 59.12 per cent to 57.73 per cent.

At Morning the average silver content in concentrates was 14.69 ounces in 1914 and 15.49 ounces in 1915. The average lead content was 44.67 per cent in 1914 and 46.14 per cent in 1915.

At Frisco the average silver content in the lead concentrates was 7.64 ounces and the lead content was 25.95 per cent. The average zinc content in the zinc concentrates was 40 per cent. * * *

The total amount of development work for the year in drifting, raising, sinking, and crosscutting was 12,154 feet, in proportion among the different properties as follows: Wardner, 3,364 feet; Morning, 3,781 feet; Federal Mace, 1,154 feet; Frisco, 1,314 feet; and Green Hill Cleveland, 2,541 feet. * * *

New equipment consisted principally in installation of a Dorr thickener and Oliver filter press at the Morning, and Garfield rolls, Janney flotation unit of nine machines, and a 6-foot Hardinge ball mill at the Frisco property. Acid flotation at the Green Hill was discontinued. * * *

Reserves at Wardner were estimated at 25,000 tons of milling ore and 450 tons of crude ore; at Morning 752,300 tons of milling ore and 62,685 tons of crude ore; at Mace 87,700 tons of milling ore and 4,390 tons crude ore; at Frisco 181,600 tons of milling ore; at Green Hill Cleveland 14,500 tons of milling ore and 445 tons of crude ore.

The Snow Storm mine and mill at Larson were idle in 1915, but a considerable quantity of crude ore and concentrates which had been stored were marketed during the year. The milling plant has since been moved to a property acquired by this company near Troy, Mont. The production from 1904 to 1915 was over 4,000,000 ounces of silver and nearly 55,000,000 pounds of copper, as well as gold valued at more than $67,000.

The Gold Hunter Mining and Smelting Co., which owns a concentration and flotation plant with a capacity of 340 tons, was operated practically the whole year, and an increased production of both silver and lead was made.

[1] Federal Mining & Smelting Co. Ann. Rept. for year ending Dec. 31, 1915.

According to the report filed with the county assessor, the mine produced 118,764 tons of ore, which had a gross value of $614,590. Cost of extraction was $368,613; freight and treatment, $77,992; betterment and repairs, $136,323; and net profit, $31,662. This is the first time the mine appears on the list with a net profit. A short article[1] on flotation, giving the flow sheet of the mill, appeared in December.

The Gold Hunter mill at the present time treats about 310 tons of ore per 24 hours. From this about 35 tons of concentrates are produced, about half of which come from the flotation department. While under the former system of table and vanner concentration, only about 50 to 60 per cent of the valuable minerals could be recovered, with the addition of the flotation units the total extraction has risen to 80 per cent, thus making it entirely clear what a great difference has been made by the introduction of flotation in this district.

The National Copper Mining Co., owning a 500-ton cencentration and flotation plant, operated its mine 150 days and the mill 50 days. The winze was sunk from the 1,000-foot to the 1,200-foot level and several shipments of copper concentrates, containing gold and silver, were made. The flow sheet of the mill was printed with a recent article[2] on flotation.

The Alice mine was operated for a short period by lessees and several shipments of lead ore were made. A shipment of concentrate was made by the American Slime Concentrating Co.

Lelande district.—Six deep mines produced 549,241 tons of ore, $13,147 in gold, 4,093,933 ounces of silver, 339,300 pounds of copper, 103,211,386 pounds of lead, and 5,642,520 pounds of zinc (spelter), having a total value of $7,698,756, or $14.02 per ton. This was a small decrease from the output in 1914, when the district produced metals valued at $8,183,621. This decline was due to the fact that the Hercules mine was idle several months in 1915. Of the district output of ore, 32,548 tons were shipped to smelters and 516,693 tons were concentrated and produced 79,381 tons of concentrates.

Notwithstanding the Hercules mine being closed during June, July, and August, the property averaged nearly 17,000 tons of milling ore a month, and at the same time shipped nearly 1,000 tons of crude ore a month. During the latter part of the year the mill near Wallace was treating about 800 tons a day. According to the statement filed with the county assessor, the Hercules produced 49,441 tons of shipping product, that is, combined crude ore and concentrates, having a gross value of $3,090,175. The cost of extraction was $950,852; freight and treatment, $986,219; betterment and repairs, $57,084; and net profit, $1,096,020. This mine was the ranking lead producer of the region in gross value of output in 1914, but both the Interstate-Callahan and the Bunker Hill & Sullivan took precedence over it in 1915. According to the State mine inspector[3] the famous ore shoot has continued to expand materially, and now, at a depth of over 2,000 feet, is practically three times as long as it was in No. 2 tunnel. It still maintains its remarkable segregation of clean, soft lead sulphide, rich in silver, and carrying less sphalerite than in No. 4 horizon.

[1] Flotation at Gold Hunter mill: Eng. and Min. Jour., Dec. 25, 1915, p. 1044.
[2] Callow, J. M., Callow flotation process: Eng. and Min. Jour., Dec. 4, 1915, p. 919.
[3] Bell, R. N., op. cit., p. 48.

During the year the Hecla mine was operated for 308 days and the mill for 333 days. The plant has been increased to a capacity of 425 tons and flotation equipment has been added. The company frankly gives any information in regard to the property, and published in substance the following statistics of production for 1915.[1]

From the Hecla mine, 146,675 tons were mined, 112,646 tons milled, 11,015 tons crude lead ore shipped, and 15,199 tons of lead concentrates shipped. Shipments resulted in a production of 692,444 ounces of silver and 24,917,867 pounds of lead. Development work during the year amounted to 3,411 feet. Drifting the full length of the ore body on the 1,600-foot level, which is the lowest one, met with most satisfactory results. On this level electric haulage has been substituted for mules. A conservative estimate of the ore reserves gives 1,110,000 tons of ore, said to be sufficient for six years' production at the present rate. According to the statement to the assessor, 146,675 tons were extracted, having a gross value of $1,422,578. Cost of extraction was $388,340; freight and treatment, $393,587; betterment and repairs, $46,971; and net profit, $593,680.

From the Greenhill-Cleveland property crude lead ore and lead-zinc ore were shipped, and lead concentrates and lead-zinc concentrates were made at the plant near Wallace. The mill treats 500 tons daily and uses concentration and flotation. According to the statement filed with the assessor, the tonnage was 28,126, which must represent a combination of crude ore and concentrates. The gross value of the products was $1,643,798; cost of extraction, $658,941; freight and treatment, $415,228; betterment and repairs, $8,592; and net profit, $497,864. Further information is given under the Hunter district by the Federal Mining & Smelting Co., which owns a large interest in this company.

The Frisco mine, owned by the Federal Co., shipped a considerable quantity of both lead and zinc concentrates. The plant has a capacity of 400 tons a day, using wet concentration, pneumatic flotation, and magnetic separation. The plant was undergoing rehabilitation until May 1. It was operated nearly all the rest of the year. According to the statement given to the county assessor, this Federal property was operated at a loss. Further information is given under the Hunter district.

From the Marsh mine, at Burke, crude lead ore and concentrates were produced the last six months of 1915. During the first part of the year work at the mine was confined to completing the new underground hoisting plant and shaft sinking. At the mill at Black Cloud, in Nine-Mile Canyon, above Wallace, extensive improvements were made, bringing the capacity up to 250 tons and adding flotation machines. The company's statement to the assessor reported a net loss in operations during 1915.

Ore reserves[2] partially blocked out December 31, 1915, approximate 35,000 tons.

The general depth [and] breadth of the exploration and development work performed, with the exception of the Got 'Em Now crosscut, has been confined to following various spurs from the main vein, together with some short crosscuts, all of which have failed to expose any commercial ore. Very limited funds have been available for such exploration work.

[1] Wallace Miner, Apr. 13 and Apr. 27, 1916.
[2] Weekly Press-Times Mining Review, Apr. 28, 1916.

Present indications are that the net proceeds from the mining of ore reserves now exposed will not provide any surplus funds for a continuation of the operation and development of the property.

A problem that must now be decided by the trustees is whether or not further exploration work is to be carried on either by sinking or exploring new ground, and if so, the manner of providing funds for such work. The operations of the present ore reserve are necessarily limited.

There were 3,393 tons of crude ore and concentrates containing 91,933 ounces of silver and 3,580,681 pounds of lead, or an average of 23.02 ounces of silver per ton and 44.83 per cent lead. The gross value of shipments was $225,861, less $82,220, costs of freight, treatment, and marketing, and the net value was $143,641.

Lessees made a few shipments of lead and lead-zinc ore from the Tiger-Poorman property of the Federal Co. at Burke, and ore was also mined at the Mace property of the Federal Co. by the Greenhill Cleveland Co. under agreement. The assessor's statement gave 52,958 tons extracted from the Mace, or Standard-Mammoth mine, having a gross value of $332,794. The cost of extraction was $205,296; freight and treatment, $88,206; net profit, $39,292.

Placer Center district.—Four deep mines produced 202,370 tons of ore, $4,327 in gold, 772,511 ounces of silver, 85,207 pounds of copper, 24,315,801 pounds of lead, and 13,672,286 pounds of zinc (spelter), valued at $3,249,107, or $16.06 per ton. The value of the production in 1914 was $1,455,953. Of the ore, 189,460 tons were concentrated and made 39,366 tons of concentrates, which, with 9,150 tons of crude ore, were shipped to various smelters. During the year the Success mine changed hands and the capacity of the concentration plant was increased to 350 tons, and various other improvements were made. The plant treated approximately 8,000 tons of ore a month and shipped about 1,800 tons of concentrates, principally zinc, a month. According to the statement to the county assessor, the Success mine produced 21,867 tons of lead and zinc concentrate, having a gross value of $1,255,801. The cost of extraction, which includes the cost of freight, treatment, and betterments, was $356,865, and the net profit was $898,936. According to a statement sent stockholders, the ore shoot has been located on the 1,200-foot level and shows 7 feet of 25 per cent zinc ore. The shaft has been extended about 100 feet to the 1,300-foot level, and a crosscut will be run to the vein from that level. An aerial tramway was ordered in August.

The Tamarack & Custer Consolidated Mining Co. made an increased production of both crude ore and concentrates. The company leased and operated the old Rex mill. According to the county assessor's figures, 26,147 tons of shipping product were made, having a gross value of $1,238,754. Cost of extraction was $449,041; freight and treatment, $439,157; betterment and repairs, $3,670; and net profit, $346,796. No dividends were paid in 1915, as part of the profits were said to have been invested in the smelter at Northport, Wash., and in the refinery at Carnegie, Pa. It was decided to build a concentration plant instead of leasing the Rex mill. The smelter contract with the American Smelting & Refining Co. will expire in 1916. Details of the development at the mine and of the shipments were not published.

Aside from these two properties, a considerable quantity of old tailings was concentrated on Nine Mile to make a zinc product,

and a shipment of copper sulphide ore was made from the Castle Rock mine, south of Wallace. There was no output from the Rex (16 to 1) property, but the company was reorganized into the Rex Consolidated Mining Co., and an option taken on the Black Bear property. The Rex mine is developed to a depth of 1,150 feet, with 6,000 feet of underground work. It has been a producer of importance, and it is planned to develop it further.

St. Joe district.—Some placer gold was taken from the Slim Show property, and several shipments of oxidized copper ore, containing gold and silver, were made from the Richmond property, where considerable development was done.

Summit district.—Six deep mines produced 2,639 tons of ore, $549 in gold, 1,124 ounces of silver, 214,554 pounds of lead, and 608,441 pounds of zinc (spelter), having a total value of $86,650, against $22,708 in 1914. The Terrible Edith was the leading producer, several hundred tons of first-class lead ore and zinc ore having been shipped. Lead concentrates and zinc concentrates came from the Monarch, Paragon, and Black Horse properties, and one shipment of lead ore from the Bear Top and Orofino.

Yreka district.—Twelve deep mines produced 996,186 tons of ore, $12,435 in gold, 4,826,413 ounces of silver, 890,720 pounds of copper, 144,506,787 pounds of lead, and 398,480 pounds of zinc, having a total value of $9,456,533. This is an increase of $299,413 over 1914, and was by far the largest total value produced by any district in the State. Of the ore sold or treated, 980,529 tons were reduced to 118,798 tons of concentrates, and 15,657 tons were shipped directly to smelters. The Bunker Hill & Sullivan remained the largest lead producer of the State, shipping at the rate of over 5,000 tons of concentrates a month and increasing the lead output approximately 10 per cent. According to the statement given to the county assessor, 454,205 tons of ore were extracted from the property, having a gross value of $4,177,819. Cost of extraction was $1,119,584; freight and treatment, $1,793,276; betterment and repairs, $136,746; and net profit, $1,145,855, which includes royalties of $17,642. The following excerpts are taken from the printed report.[1]

Since we have practically 10 years' ore supply in the mine and our deep development work and geological conditions are highly favorable for additional decades of mining life, we are fully justified in making plans to substantially increase our output and to provide smelting facilities of our own for the better conserving of the metals in our own ores and the ores of our affiliated mining companies for which a satisfactory market can not be found. * * *

The ore reserves to date total 3,573,930 tons. * * *

The mine was in operation for the full period of 12 months and produced 450,182 tons of concentrating ore and 5,023 tons from exploration at a cost of $908,868.

Forty-seven hundred and eighty-three feet of drifts, crosscuts, and raises were driven, at a cost of $34,997. * * *

The concentrators were in operation for the full year. * * *

During the year 441,854 tons of ore were concentrated, making the average work of the concentrators 1,210 tons per day, or, say, 1,241 tons per 24 hours of actual operation, at a cost or $193,377. * * *

The ore milled—454,636 tons—assayed 9.94 per cent lead and 3.83 ounces of silver. From this tonnage, 59,901 tons of concentrates were produced, containing 74,584,741 pounds of lead and 1,298,284 ounces of silver. The loss in tailings was 17.48 per cent of the lead and 25.39 per cent of the silver in ore milled,

[1] Bunker Hill & Sullivan Mining & Concentrating Co. Ann. Rept. for year ending Dec. 31, 1915.

or a total loss of 18.79 per cent. From 1886 to 1915 the company has mined 6,918,072 tons of ore having a gross value of $64,409,361. Net smelter returns were $38,733,799 and operating profit $21,082,573.

According to C. E. Siebenthal,[1] of the United States Geological Survey—

> The company decided in 1915 to build a complete lead smelter and refinery. Kellogg, Idaho, was finally selected as the place and construction has begun on a site a mile west of the Bunker Hill mine. The roasting department will consist of a 26-foot Wedge roaster and four 42-inch Dwight & Lloyd sintering machines. There will be three lead furnaces 48 by 180 inches in size, each having a 20-foot 6-inch smelting column. The capacity of each will be 300 tons a day. The bullion will be drawn hot from the blast furnaces by an electric crane to the refinery, which will use the Parkes process of zinc desilverization and will be equipped with two softening furnaces, four desilverizing kettles, two refining furnaces, four merchant kettles, a hard-lead furnace, and a drossing furnace. The silver refinery will have four Faber du Faur retorts, two coupling furnaces, a fine-silver furnace, and a crucible furnace for gold smelting. Doré bars will be parted by the sulphuric-acid process, the silver precipitated by copper, and the resulting copper sulphate crystallized and sold. The gases from the blast furnaces, roasters, and refinery furnaces will be passed through a bag house, and the filtered gases will escape from a 12-foot concrete stack 200 feet in height.

The Stewart Mining Co. operated its mine at Kellogg and its leased mill near Wallace the entire year. According to the statement made to the county assessor, there were 180,017 tons of ore extracted, having a gross value of $1,557,627. Cost of extraction was $472,893; freight and treatment, $511,387; repairs, $1,115; and net profit, $572,232. A statement to stockholders published in January[2] gave the following information:

> The ore bodies in the Stewart mine which have produced so satisfactorily for several years are, of course, being reduced and must finally be worked out. New development work is constantly in progress to open new ground. Our manager advises us that he has sufficient ore blocked out to keep our mine organization busy during the winter, and that in the course of the exploratory and development work now being done in the Legal Tender and Crown Point claims of the Coeur d'Alene property, several small ore bodies have been uncovered and promising indications of soon striking larger and more persistent veins have been found.
>
> Because of the uncertainty as to the supply of ore to be found in the claims now owned or controlled by your company, our engineers have been examining other mines and mining prospects which have been brought to our attention, with the object of acquiring a new property to insure the continuous paying operations of your company for many years to come.

The Last Chance mine, belonging to the Federal Co. was operated throughout the year. The ore is hand sorted and treated by wet concentration, after which tailings are treated by pneumatic flotation for saving fine lead. According to the statement to the county assessor, 136,180 tons were extracted, having a gross value of $620,682. Cost of extraction was $369,083; freight and treatment, $204,229; and net profit, $47,370. It is said that the part of this property still remaining under the control of the Federal Co. is nearly exhausted.

The Sierra Nevada property produced a considerable quantity of silver-lead concentrate. The mine production was stopped at the end of April, 1915. The upper workings of the mine are under lease for reworking fillings in the old stope. The statement to the assessor gave 15,159 tons extracted, with a gross value of $110,328.

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[1] Siebenthal, C. E., U. S. Geol. Survey Mineral Resources, 1915, pt. 1, p. 194, 1916.
[2] Wallace Miner, Jan. 20, 1916.

Cost of extraction was $63,973 and net profit $46,355.. The property is controlled by the Bunker Hill & Sullivan Co., and the following statement is made in the report[1] of that company:

The Sierra Nevada Consolidated Mining Co. began production in July, 1913, selling all its output under a satisfactory contract with the American Smelting & Refining Co. This contract expired April 29, 1915, and the smelting company refused to renew or extend it, or to receive the Sierra Nevada Co.'s ores other than under new terms equivalent to an advance of some $4 to $6 per ton, as the metal market might be. As it has not been possible to find a market with any other smelting company for these ores at the former rate, or at what seemed a fair rate, the Sierra Nevada Co. has not sold any ore since April 29, 1915. Production was discontinued at that date and only moderate exploration and maintenance work has been done since. There are considerable reserves of ores in the workings and the future mining chances are good.

At the Ontario property, near Kellogg, both crude lead ore and concentrate were marketed and a 300-ton concentration plant was operated. The apex litigation with the Stewart Mining Co. was settled during the year in favor of the Ontario Co. According to the statement to the assessor, 81,208 tons of ore were extracted, having a gross value of $689,392. Cost of extraction was $265,728; freight and treatment, $199,939; and net profit, $223,725.

The mine and mill of the Caledonia Mining Co. were operated the entire year and the production was greatly increased. The ore is exceptionally rich in silver and contains more copper than the ore of neighboring properties. One or two shipments of copper sulphide ore were also made. According to the statement to the assessor, 42,628 tons were extracted, having a gross value of $1,246,860. The cost of extraction was $107,575; freight and treatment, $378,960; and net profit, $761,797.

In discussing the condition of the Caledonia mine[2] and the big showing of ore that has just been disclosed on the 1,000 level the manager stated that there is enough ore now available in the mine to continue running at the present capacity for three years. The drift on what is now called the 1,000-foot level, running from the bottom of the winze which has since been connected by an upraise and which is part of the outlet to the Kellogg tunnel of the Bunker Hill has been driven through ground that is very faulty and which at times rendered it difficult to follow the vein. The amount of ore varied, the conditions being practically the same as had been encountered in the upper levels. Within the last few days the ore has come in stronger until there is now fully 7 feet of shipping ore, with probably as much of milling grade. The ore is galena, none of the rich carbonate that has made the Caledonia famous having been found on this level.

There are now about 35 men employed in the Caledonia, but the average number during the past year was 30. These men are working on all the levels from the 1,000 to above the 500. In the upper levels only the high grade has been mined and large quantities of good mill feed remain in all, including the 300. A crosscut will soon be run to cut the ore shoot just disclosed on the 1,000-foot level of the Keating tunnel level with every prospect of finding it. The Keating tunnel is about 75 feet below the 1,000-foot level. The present showing in the Caledonia appears to be better than ever before, and there is every reason to expect that its rich ore bodies will continue at great depth.
* * *

The output in 1915 was 15,005 dry tons of crude ore and concentrates, 11,144,000 pounds of lead, 1,212,730 ounces of silver, and 659,660 pounds of copper, with a gross value of $1,246,860.

For testing purposes ore from the Crown Point group of the Coeur d'Alene Development Co. was concentrated in the Stewart

[1] Bunker Hill & Sullivan Mining & Concentrating Co. Ann. Rept. for year ending Dec. 31, 1915.
[2] Wallace Miner, Jan. 27, 1916.

mill. The Big Creek Mining Co. produced several shipments of ore containing an average of about 90 ounces of silver per ton, but low in lead. The Constitution mine, on Pine Creek, made several shipments of good grade zinc sulphide. A shipment of rich lead-carbonate came from Hypotheek mine, which is being developed on the 900-foot level. The Highland Surprise mine was operated for a short time, and both lead concentrates and zinc concentrates produced at the 150-ton concentration plant. Ore said to average 5 per cent copper was developed at the Horst-Powell property on the Little North Fork, and several shipments were made to Tacoma for testing purposes. Zinc ore was opened at the Little Pittsburg property, on Pine Creek, and a 250-ton concentration plant was being erected in December by the Colonial Mining Co. The Douglas mine on Pine Creek has a large tonnage of lead-zinc ore blocked out, which is said to assay 6 per cent lead and 17 per cent zinc. The property was bonded by the Anaconda Copper Co., of Butte, Mont., and it is planned to send ore to the electrolytic zinc plant at Great Falls.

TWIN FALLS COUNTY.

Five placer operators on the banks of Snake River produced $1,662 in gold and 8 ounces of silver, valued in all at $1,666.

PUBLICATIONS.

A list of the publications of the United States Geological Survey on metalliferous resources in Idaho was published in the report for 1914.[1]

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 639, 1915.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN WASHINGTON.

(MINES REPORT.)

By C. N. Gerry.

PRODUCTION.

GENERAL STATEMENT.

The value of the mine production of gold, silver, copper, lead, and zinc in Washington in 1915 was $744,033, a decrease of about 8 per cent. There was increase in copper and lead and a production of zinc for the first time since 1911, but decrease in gold, silver, and the quantity of ore sold or treated. Since 1860, the State has produced gold, silver, copper, lead, and zinc valued at $32,000,000, of which 82 per cent was for gold. The production by years from 1860 to 1913 was given in the report for 1913.[1]

Mine production of metals in Washington in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	67	95,947	$557,173	264,861	778,728	65,507	.....	$809,767
1915	104	86,677	391,419	255,837	1,020,926	295,215	244,906	744,033
Increase or decrease, 1915	.....	−9,270	−165,754	−9,024	+242,198	+229,708	+244,906	−65,734
Total, 1860–1915	.....	.....	26,378,713	6,435,999	6,078,260	12,068,143	265,496	32,149,031

PRODUCTION OF ORE.

The quantity of ore sold or treated decreased from 95,947 tons in 1914 to 86,677 tons in 1915, or nearly 10 per cent. This decrease was due almost entirely to the lessened output of Ferry County. The total value per ton of the ore increased from $8.38 in 1914 to $8.50 in 1915, but the value per ton in gold and silver decreased from $7.27 to $5.93. The output of dry or siliceous ore decreased from 77 per cent to 49 per cent of the total ore, but the copper ore increased from 23 per cent to nearly 47 per cent of the total. Siliceous ore averaged

[1] U. S. Geol. Survey Mineral Resources, 1913, pt. 1, p. 790, 1914.

$10.77 in gold and silver, and copper ore $1.36 in the same metals. Lead ore was only a little more than 1 per cent and zinc ore nearly 4 per cent of the total. The siliceous ore was composed of 41,412 tons of gold ore, averaging per ton $9.09 in gold, 2.41 ounces of silver, 0.029 pound of copper, and 0.002 pound of lead; and 748 tons of silver ore averaging per ton $1.49 in gold, 67.94 ounces of silver, 16.38 pounds of copper, and 0.22 pound of lead. The gold ore includes 4,077 tons of sulphide iron ore containing 25 ounces of gold, 59 ounces of silver, and 1,041 pounds of copper. The total siliceous ore, inclusive of iron ore, averaged per ton $8.96 in gold, 3.57 ounces of silver, and 0.3 pound of copper. Copper ore as mined averaged per ton 16 cents in gold and 2.37 ounces of silver, and contained 1.25 per cent of copper. Lead ore averaged per ton 5 cents in gold and 9.45 ounces of silver, and contained 14.91 per cent of lead. Zinc ore milled and shipped averaged per ton 3.94 per cent zinc calculated as spelter recovered. Most of the copper ore and zinc ore was concentrated, but only a small part of the siliceous ore and lead ore was treated in mills. Of the shipping ore, the copper ore—8,538 tons—and the lead ore—689 tons—were sulphides.

Ore and metals produced in Washington in 1915.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	31	.....	346.36	94	.....	.....	.....
Dry or siliceous ore	56	42,160	18,277.72	150,633	13,451	249	.....
Copper ore	11	40,417	308.59	95,766	1,007,475	.....	.....
Lead ore	6	989	2.23	9,344	.....	294,966	.....
Zinc ore	1	3,111	.....	.....	.....	.....	244,906
	.....	86,677	18,934.90	255,837	1,020,926	295,215	244.906

Ore sold or treated from Washington in 1915, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Total.
Chelan	646	1	.....	.....	647
Ferry	39,060	5,939	.....	.....	44,999
Kittitas	9	.....	.....	.....	9
Okanogan	1,126	213	300	.....	1,639
Pend Oreille	.....	.....	.....	3,111	3,111
Pierce	.....	5	.....	.....	5
Snohomish	148	104	.....	.....	252
Stevens	176	34,155	689	.....	35,020
Whatcom	995	.....	.....	.....	995
	[a]42,160	40,417	989	3,111	86,677
Average value per ton in gold and silver	$10.77	$1.36	$4.83	.....	$5.93

[a] Includes 41,412 tons of gold ore and 748 tons of silver ore.

Ten milling plants were active in 1915, but nearly all of them were operated for short periods only. The United Copper mill was active most of the year, though additions to the plant were being made. Of the total mills, 4 used cyanidation, 3 concentration, and 3 amalgamation.

Gold and silver mills treated a little more than 3 per cent of the total tonnage, or 2,732 tons, in 1915, against 24,533 tons in 1914. The San Poil mill at Republic, active in 1914, was idle most of 1915. About 28 pounds of mercury, 1,200 pounds of potassium cyanide, and 3,400 pounds of sodium cyanide were consumed at these mills. The average was nearly the same as in 1914, or 0.02 pound of mercury per ton of ore amalgamated and 2.6 pounds of cyanide per ton of ore and tailing cyanided.

Gold and silver produced in mills in Washington in 1915.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Chelan	307	5.26	.....	[a]122.10	[a]58	$2,663
Ferry	1,044	.....	.....	478.93	4,259	12,059
Kittitas	9	10.94	5	.....	.....	229
Okanogan	377	178.59	72	75.00	27	5,292
Whatcom	995	582.01	42	.....	.....	12,052
	2,732	776.80	119	676.03	4,344	32,295

[a] Includes bullion from 300 tons of old tailings.

Ore concentrated increased from 13,581 tons in 1914 to 35,210 tons in 1915, or more than 40 per cent of the total ore. The resulting concentrates increased from 1,589 tons in 1914 to 2,584 tons in 1915. The Chewelah district, as formerly, produced most of the concentrates, a copper product, but in 1915 zinc concentrates from Pend Oreille County were also marketed. An increase in both products can be reasonably expected in 1916. Copper concentrates averaged per ton 28 cents in gold and 28.79 ounces of silver, contained 9.62 per cent of copper, and had an average value per ton of $48.55. Lead concentrates averaged per ton 29.41 ounces of silver, contained 15.79 per cent of lead, and had a value per ton of $29.75. Zinc concentrates averaged 41.55 per cent zinc (spelter) and had a value per ton of $103.04.

Mine production of metals from Washington concentrates [a] in 1915.

County.	Ore to concentrating mills.	Concentrates.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value of concentrates.
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Okanogan	300	73	.....	2,147	.....	23,051	.....	$2,172
Pend Oreille	3,031	234	.....	.....	.....	.....	194,451	24,112
Stevens	31,879	2,277	31.06	65,559	438,151	.....	.....	110,556
	35,210	2,584	31.06	67,706	438,151	23,051	194,451	136,840

[a] The concentrates from Okanogan County were all lead concentrates in 1915, those from Pend Oreille were all classified as zinc concentrates, and those from Stevens were all copper.

Nearly 56 per cent of the ore was shipped directly to various smelters. Of this total nearly 81 per cent was siliceous, nearly 18 per cent was copper ore, more than 1 per cent was lead ore, and only 80 tons was zinc ore. The siliceous ore shipped to smelters averaged per ton $8.89 in gold, 3.73 ounces of silver, and 0.4 pound of copper, and was valued at $10.84. Copper ore shipped averaged per ton 67 cents in gold, 3.54 ounces of silver, contained 3.33 per cent of copper, and was valued per ton at $14.13. First-class lead ore shipped had an average assay of 7 cents in gold, 10.44 ounces of silver, and 19.73 per cent lead, and was valued per ton at $23.91. Crude zinc ore shipped averaged 31.53 per cent zinc (spelter), and had a value per ton of $78.20. Both copper and lead ores were sulphides, but the zinc ore shipped was oxidized.

Mine production of metals from Washington crude ore shipped to smelters in 1915.

By counties.

	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Chelan	40	72.00	26	117	.....	.....	$1,521
Ferry	43,955	16,547.76	99,213	317,396	162	.....	447,926
Okanogan	962	230.25	39,604	43,106	87	.....	32,387
Pend Oreille	80	.....	.....	.....	.....	50,455	6,256
Pierce	5	.....	24	1,422	.....	.....	261
Snohomish	252	117.21	522	41,226	.....	.....	9,903
Stevens	3,141	137.43	44,185	179,508	271,915	.....	69,437
	48,435	17,104.65	183,574	582,775	272,164	50,455	567,691

By kinds of ore.

Dry or siliceous	39,128	16,824.89	146,170	13,451	249	.....	$424,276
Copper	8,538	277.53	30,207	569,324	.....	.....	120,684
Lead	689	2.23	7,197	.....	271,915	.....	16,475
Zinc	80	.....	.....	.....	.....	50,455	6,256

GOLD.

The mine production of gold was valued at $391,419, against $557,173 in 1914, a decrease of $165,754. Of this total, more than 90 per cent was derived from ores shipped directly to smelters, nearly 8 per cent came from ores treated by amalgamation or cyanidation, nearly 2 per cent was from placers, and less than 1 per cent was from concentrates. The table below shows that siliceous ore supplied most of the gold, or about 96 per cent, and that copper ore contained nearly 2 per cent of the total. The decrease in siliceous ore was 8,176.14 ounces.

Mine production of gold in Washington in 1915, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Total.
Benton	8.03	.....	.....	.....	8.03
Chelan	7.64	199.36	.....	.....	207.00
Clallam	33.14	.....	.....	.....	33.14
Ferry	.....	16,834.69	192.00	.....	17,026.69
Kittitas	182.08	10.94	.....	.....	193.02
Okanogan	13.50	473.53	10.31	.....	497.34
Snohomish	50.26	93.99	23.22	.....	167.47
Stevens	28.06	83.20	83.06	2.23	196.55
Whatcom	23.65	582.01	.....	.....	605.66
	346.36	[a]18,277.72	308.59	2.23	18,934.90

[a] Includes 18,223.36 ounces from gold ore and 54.36 ounces from silver ore.

SILVER.

The mine production of silver decreased from 264,861 ounces, valued at $146,468, in 1914 to 255,837 ounces, valued at $129,709, in 1915. The decrease in Ferry County was mostly offset by increases in Okanogan and Stevens counties. Crude ore shipped to smelters supplied nearly 72 per cent of the total, concentrates more than 26 per cent, bullion nearly 2 per cent, and placers only 94 ounces. Siliceous ore contained nearly 59 per cent, copper ore more than 37 per cent, and lead ore nearly 4 per cent.

Mine production of silver in Washington in 1915, in fine ounces.

County.	Placers.	Dry or siliceous ore.	Copper ore.	Lead ore.	Total.
Benton	2	.....	.....	.....	2
Chelan	.....	74	10	.....	84
Clallam	6	.....	.....	.....	6
Ferry	.....	102,307	1,165	.....	103,472
Kittitas	62	5	.....	.....	67
Okanogan	2	38,735	968	2,147	41,852
Pierce	.....	.....	24	.....	24
Snohomish	8	186	336	.....	530
Stevens	6	9,284	93,263	7,197	109,750
Whatcom	8	42	.....	.....	50
	94	[a] 150,633	95,766	9,344	255,837

[a] Includes 99,811 ounces from gold ore and 50,822 ounces from silver ore.

COPPER.

The mine production of copper increased from 778,728 pounds, valued at $103,571, in 1914 to 1,020,926 pounds, valued at $178,662, in 1915. The production increased in nearly every county, but especially in Ferry County. Crude ore produced 57 per cent and concentrates nearly 43 per cent. Most of the metal came from copper ore, with only a little more than 1 per cent from siliceous or iron ore.

Mine production of copper in Washington in 1915, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Total.
Chelan		117	117
Ferry	3,702	313,694	317,396
Okanogan	9,749	33,357	43,106
Pierce		1,422	1,422
Snohomish		41,226	41,226
Stevens		617,659	617,659
	[a] 13,451	1,007,475	1,020,926

[a] Includes 1,200 pounds from gold ore and 12,251 pounds from silver ore.

LEAD.

The mine production of lead increased from 65,507 pounds, valued at $2,555, in 1914 to 295,215 pounds, valued at $13,875, in 1915. Galena from Stevens County was the source of most of it. Crude ore contained 92 per cent and concentrates the remainder.

ZINC.

The mine production of zinc (calculated as spelter) was 244,906 pounds, valued at $30,368, in 1915. There had been no zinc produced since 1911. It came entirely from Pend Oreille County, but a zinc ore shipment will be made from Stevens County in 1916. More than 79 per cent came from concentrates.

MINING INDUSTRY.

Mining was comparatively quiet in Washington during the first half of the year, but later it began to respond to the reaction of the metal market. Several old properties were reopened when prices of metals increased. Milling capacity at Chewelah was increased; but it is not probable that the cyanidation mills at Republic will be operated in the near future, as the siliceous ore of that district is in great demand as a smelting flux, and freight rates are being greatly reduced. The Northport smelter, remodeled and enlarged in 1914, is another purchaser of this class of ore. The zinc resources of the State are becoming important. The shipments for 1915 are the first to be made, with the exception of a small shipment in 1911. An important discovery of high-grade galena was made at the Electric Point mine, near Northport. The mines of Okanogan County have been stimulated by the completion of the branch of the Great Northern Railway from Wenatchee, in Chelan County, to Oroville, in Okanogan County, near the Canadian border.

Mine production of metals in Washington in 1915.

County.	Ore.	Gold.		Silver.	
		Quantity.	Value.	Quantity.	Value.
	Short tons.	*Fine ounces.*		*Fine ounces.*	
Benton		8.03	$166	2	$1
Chelan	647	207.00	4,279	84	43
Clallam		33.14	685	6	3
Ferry	44,999	17,026.69	351,973	103,472	52,460
Kittitas	9	193.02	3,990	67	34
Okanogan	1,639	497.34	10,281	41,852	21,219
Pend Oreille	3,111				
Pierce	5			24	12
Snohomish	252	167.47	3,462	530	269
Stevens	35,020	196.55	4,063	109,750	55,643
Whatcom	995	605.66	12,520	50	25
	[a] 86,677	18,934.90	391,419	255,837	129,709

County.	Copper.		Lead.		Zinc (spelter).		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Benton							$167
Chelan	117	$20					4,342
Clallam							688
Ferry	317,396	55,544	162	$8			459,985
Kittitas							4,024
Okanogan	43,106	7,544	23,138	1,087			40,131
Pend Oreille					244,906	$30,368	30,368
Pierce	1,422	249					261
Snohomish	41,226	7,215					10,946
Stevens	617,659	108,090	271,915	12,780			180,576
Whatcom							12,545
	1,020,926	178,662	295,215	13,875	244,906	30,368	744,033

Though the number of producers increased considerably, the tonnage of ore treated continued to decrease. The value of the ore was upheld by better prices for metals.

Ore sold or treated, deep mines producing, and average value of ores in Washington.

County.	Ore sold or treated, 1915.		Number of deep mines producing.		Average total value per ton.[a]		Average value per ton in gold and silver.[a]	
	Quantity.	Increase or decrease.	1914	1915	1914	1915	1914	1915
	Short tons.	*Short tons.*						
Chelan	647	+ 383	3	9	$6.08	$6.47	$6.02	$6.44
Ferry	44,999	−23,085	17	27	9.18	10.22	8.87	8.99
Kittitas	9	+ 4	2	2	40.80	25.44	40.80	25.44
Okanogan	1,639	+ 919	12	17	14.14	24.31	9.96	19.05
Pend Oreille	3,111	+ 3,111		1		9.76		
Pierce	5	+ 5		1		52.20		2.40
Skamania		− 1	1		22.00		3.00	
Snohomish	252	− 243	2	2	15.78	39.30	15.60	10.67
Stevens	35,020	+10,484	11	12	5.87	5.14	2.55	1.69
Whatcom	995	− 847	2	2	8.08	12.11	8.08	12.11
	86,677	− 9,270	50	73	8.38	8.50	7.27	5.93

[a] Value per ton, placer product excluded.

Thirty-one placer mines produced in 1915, of which 27 were worked by hydraulic or sluicing methods and 4 by drifting. Of the 73 deep mines, 37 produced gold and silver; 18, gold, silver, and copper; 8, silver and lead; 6, gold alone; 3, silver alone; and 1, zinc.

REVIEW BY COUNTIES.

BENTON COUNTY.

A few ounces of gold and silver were taken from Columbia River, near Finley, during experimentation on a process to save the fine gold.

CHELAN COUNTY.

From 2 placers and 9 deep mines the county output was 647 tons of ore—$4,279 in gold, 84 ounces of silver, and 117 pounds of copper—valued at $4,342, an increase from the output of 1914, which was 264 tons of ore, valued at $1,604. Most of the ore, or 307 tons with 300 tons of old tailings, was treated in gold and silver mills, and produced bullion valued at $2,663. Forty tons containing gold, silver, and copper were shipped directly to smelters.

Blewett district.—Six deep mines and 2 placers produced 335 tons of ore—$2,292 in gold, 33 ounces of silver, and 117 pounds of copper—valued at $2,329. A shipment of gold ore of good grade was made from the Elephant and Ivanhoe claims, and the North Star claim of the Golden Eagle group produced ore, which was treated in a 25-ton cyanide plant. Some placer gold came from Peshastin Creek, 6 miles north of Blewett.

Chelan Lake district.—Two small lots of gold ore were shipped by the Chelan Butte Gold Mining Co.

Entiat district.—Tailings were cyanided at the old Rex property belonging to the Wenatchee Gold Mining Co. It was formerly a good producer, and the mill will probably be operated again by the Rex Development Co.

CLALLAM COUNTY.

Placer gold valued at $685 and 6 ounces of silver were taken from beach gravel in the vicinity of Royal and Ozette close to the Pacific coast.

FERRY COUNTY.

Mine production in Ferry County, Wash., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	17	68,084	$513,276	163,674	159,142	5,603	$625,173
1915	27	44,999	351,973	103,472	317,396	162	459,985
Increase or decrease, 1915	.....	−23,085	−161,303	−60,202	+158,254	−5,441	−165,188

There was decrease in gold, silver, and lead, as well as in the ore sold or treated, but there was a good increase in the output of copper. Twenty-seven deep mines produced 23,085 tons of ore less than 17 mines in 1914. The ore had a value per ton of $10.22 in all metals and of $8.99 in gold and silver, a slight increase. The greater part of the ore, or 43,955 tons, was shipped directly to smelters and had a total value of $447,926, or $10.19 per ton. The remainder, 1,044 tons, was treated in cyanide mills, having a total value of $12,059, or $11.55 per ton. Of the total quantity 39,060 tons were siliceous ore and 5,939 tons copper ore. Ferry County produced nearly 52 per cent of the total ore, nearly 90 per cent of the gold, more than 40 per cent of the silver, and 31 per cent of the copper in 1915, though the output of the county decreased $165,188 in total value. The geology of the region has been described in a bulletin of the United States Geological Survey.[1]

Belcher district.—The Belcher mine produced considerable sulphide iron ore containing small percentages in gold, silver, and copper. The production, however, was by no means as much as in past years. The Laurier Mining Co., in the same district, was getting its property in shape for later production. The ore is sulphide, containing about 20 to 30 per cent iron. An aerial tramway was installed and regular shipments begun in the early part of 1916. A little surface ore was taken from the Salina group, near Rockcut.

Danville district.—After being closed since May, 1914, the Lone Star and Washington group, operated by the British Columbia Copper Co., began operations in July and shipped considerable copper sulphide material containing gold and silver.

Enterprise district.—A shipment of silver ore was made from the Hall Creek property. The Silver Leaf property produced a small amount of scheelite, as well as a shipment of silver ore.

Keller district.—Small test shipments were made from the Gold Cord and Iron Creek properties. The former has a 15-ton concentration plant, not yet completed.

Republic district.—Nineteen deep mines produced 34,853 tons of ore, containing $347,480 in gold and 98,947 ounces of silver, valued at $397,646, or $11.41 per ton. The output of ore was 19,517 tons less than in 1914. From 1896 to the end of 1915 the Republic district produced 376,945 tons of ore, $5,734,728 in gold, and 1,650,077 ounces of silver, or a total value for both metals of $6,632,496. In 1915 only 1,044 tons of ore were treated in gold and silver mills and the remainder, or 33,809 tons, shipped directly to smelters, contained 16,330.40 ounces of gold and 94,688 ounces of silver. All of the ore was siliceous, having a value per ton of $11.41, and is in great demand at the smelters. The North Washington or White mill was idle, and the San Poil plant was operated only for a short time in January. The principal producers, according to gold content, were as follows: Surprise, Lone Pine and Pearl group, Knob Hill, Ben Hur, Tom Thumb, San Poil, Last Chance, and Old Republic. Smaller producers were the Apollo, Trade Dollar, Blacktail, Morning Glory, and Washington. The Surprise, Lone Pine, and Pearl mines were operated the entire year under the direction of the trustee appointed

[1] Bancroft, Howland, The ore deposits of northeastern Washington, with a report on the Republic mining district by Waldemar Lindgren and Howland Bancroft: U. S. Geol. Survey Bull. 550, 1914.

by the court. In February the Western Union Mines Co., which was operating the property, failed. This was followed by the organization of the West Virginia Mining Co., which went out of business in October, and was succeeded by the Republic Consolidated Mines Corporation. The average shipments for the entire year was approximately 800 tons a month, nearly all of which was shipped to Canadian smelters.

At the end of 1914 the Knob Hill mine had practically no ore developed. During 1915, under a competent management, 834 feet of drifts and crosscuts were driven and at the same time about 300 tons of ore a month was shipped. A sample lot of 38 tons averaged 2.4 ounces of gold and 7.2 ounces of silver, with a profit from the smelter of $1,545. The production for the year is reported[1] as 3,500 tons of ore, valued at $80,000. Toward the end of the year the company purchased the Alpine claim and was in good shape for a better production in the future.

The Ben Hur property, which has been operated for several years by the Ben Hur Leasing Co., was turned over to the Consolidated Mining & Smelting Co., of Trail, British Columbia, in May, 1915. The property produced more ore than any mine in the district, or approximately 1,200 tons a month for the year but as it is of lower grade it did not compete with the gold and silver production of the Knob Hill or Surprise group.

The Tom Thumb mine, belonging to the Midget Gold Mining & Milling Co., was leased and began shipping in October, 1915, at the rate of about 1,200 tons a month. The property is opened by a 400-foot incline shaft and is reported to have 10,000 tons of $10 ore.

The San Poil property was operated under the direction of a receiver and considerable ore was shipped, though not so much as in former years. In the early part of 1916 the property was under bond to the West Hill Mining Co. and was operated by that company. Several shipments of ore of good grade were made from the Old Republic property, owned by the Rathfon Reduction Works. The cyanide plant owned by this company, which was to be operated on a large dump of old tailings, was not active in 1915.

The approximate value of the ore from the Surprise, Lone Pine, and Pearl mines was given in the statement in this report for 1914.[2]

KITTITAS COUNTY.

Swauk district.—Two deep mines and 10 placers produced 9 tons of ore, $3,990 in gold, and 67 ounces of silver, in all valued at $4,024. A small quantity of ore was treated in arrastres, but the greater part of the output, amounting to $3,764 in gold and 62 ounces of silver, came from placer mines near Liberty. The principal operations were on the Hampton claim, Golden Rule, Becker, Old Bigney, and Hinton-McCauley.

OKANOGAN COUNTY.

Seventeen deep mines and 2 placers produced 1,639 tons of ore, $10,281 in gold, 41,852 ounces of silver, 43,106 pounds of copper, and 23,138 pounds of lead, valued at $40,131. There was a general in-

[1] Min. and Sci. Press, Feb. 5, 1916, p. 716.
[2] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 650, 1915.

crease amounting to $29,949 in the value of metals produced in the county. The ore increased in value per ton from $14.14 to $24.31 and the gold and silver from $9.96 to $19.05. Most of the ore, 962 tons, was shipped to smelters, 300 tons was concentrated, making a lead concentrate, and 377 tons were treated in gold and silver mills. Of the total tonnage, 213 tons represented copper ore, 300 tons lead ore, and 1,126 tons siliceous ore. Placer production was only $279 in gold and 2 ounces of silver.

Cascade or Wauconda district.—The Toroda Development Co. is said to have shipped bullion from a mill working ore at the Bodie property. Some rich silver ore was shipped from the Phil Sheridan property, belonging to the Carey Mining Co.

Conconully district.—From the Arlington property a considerable quantity of ore, rich in silver and containing some copper and gold, was shipped directly to Tacoma. This property and others in the Conconully and Ruby mining districts have recently been described.[1] Extracts in regard to the Arlington property are as follows:

> The Arlington group consists of 10 patented and several unpatented claims on the crest of Ruby Hill. The old shaft of the Arlington mine is located on the west slope of Ruby Hill about 200 feet below its summit. The vein is one of the first discoveries of the Ruby district. Two years ago the mine was reopened after a long period of inactivity. Prior to 1901 the returns on 1,000 tons of ore are reported[2] to have been $25,000. Since October, 1914, 15 carloads of ore containing 583.44 tons were shipped, from which the net returns were $17,021.71, or about $29 a ton. The average content of metals in this shipment paid for by the smelter was as follows: Gold, 0.025 ounce to the ton; silver, 75.96 ounces to the ton; and copper, 1.3 per cent.
>
> The property is developed by two tunnels at levels 240 feet apart, which have a total development over 3,000 feet. The upper tunnel connects with the old shaft that is 200 feet deep and is now being reopened for an airway. The early production of the mine came from drifts from the old shaft above the upper tunnel level, but recent shipments have been made principally from stopes in the lower tunnel. Extensive improvements have recently been made at the mine. The company erected a pole line, and electric current is transmitted from the plant of the Okanogan Valley Power Co., at Okanogan, 12 miles distant. Motors have been installed to operate the compressor and station pump used in sinking a shaft on the vein from the lower tunnel. Several mine buildings were being erected during the writer's visit. The upper tunnel is driven eastward 420 feet to the first vein and the lower crosscut tunnel is 975 feet to the vein. * * *
>
> The wall rocks are schists, gneiss, and granite, and the principal mineral is tetrahedrite or grey copper.

Methow district.—A 15-ton mill using the amalgamation process produced bullion from the property of the Montana Gold Mining Co., near Mazama. A test shipment of copper ore came from the Copper Glance property.

Meyers Creek district.—Four deep mines and 1 placer produced 371 tons of ore, $4,086 in gold, 556 ounces of silver, and 11,277 pounds of copper, in all valued at $6,341, an average of $16.50 for the ore. Fifty-seven tons were treated in gold mills and 314 tons shipped directly to smelters contained 158.29 ounces of gold, 542 ounces of silver, and 11,277 pounds of copper. Small placer production came from the Cuba claim, near Molson. A small tonnage of free gold ore from the Reco mine was treated at the Poland China mill. Rich ore containing gold, silver, and copper was shipped from the Gold Axe

[1] Jones, E. L., jr., Reconnaissance of the Conconully and Ruby mining districts, Wash.: U. S. Geol. Survey Bull. 640, pp. 11–36, 1916 (Bull. 640–B).

[2] Landes, Henry, Washington Geol. Survey Ann. Rept., vol. 1, p. 72, 1901.

property. The Western Star mine produced a few shipments of copper ore.

Nespelem district.—A small shipment of ore unusually rich in silver was shipped from the Apache property by a lessee.

Palmer Mountain district.—Seven deep mines produced 462 tons of ore, $765 in gold, 2,847 ounces of silver, 21,300 pounds of copper, and 23,138 pounds of lead, in all valued at $7,023. Of this tonnage 162 tons was shipped without treatment, and 300 tons were concentrated. A lead sulphide concentrate came from the Caaba mine and copper ore from the O. K. and 49th Parallel properties. A small shipment of rich gold ore came from the Golden Zone property. Considerable development was done on the Ivanhoe mine, near Oroville, where the ledge was said to have been encountered 4,400 feet from the portal.

Twisp district.—Prospecting work was done and slight placer production made at the Johnson group on Twisp River.

PEND OREILLE COUNTY.

Metaline district.—The Clark property, belonging to the Lead-Zinc Co., produced a good grade of zinc concentrate and oxidized crude ore. The capacity of the concentration plant was being increased to 100 tons. The old plant was only operated from July until October 15, and the new mill began operations in December. It is thought that with increased shipments from this mine and shipments from near Northport, in Stevens County, the State will have an important output of zinc in 1916. There was no production from the Metaline Oriole property.

PIERCE COUNTY.

A test shipment of copper ore came from the Mount Rainier property in Glacier Basin, near Enumclaw. A 320-foot tunnel was driven in 1915, making the total length 1,785 feet.

The Tacoma smelter is located in this county. Part of the custom material from the various mines of the State is shipped to this plant, though the greater part mined east of the mountains goes to Canadian smelters. Many improvements were made at the plant, and the new electrolytic copper refinery added is said to have a capacity of 6,000 tons of copper a month. This, with the old refinery, gives a total capacity of 8,000 tons a month. Ores are received from points in the northwest, particularly from Alaska, and also from South America.

SNOHOMISH COUNTY.

Five placers and 2 deep mines produced 252 tons of ore, $3,462 in gold, 530 ounces of silver, and 41,226 pounds of copper, valued at $10,946. The ore decreased in quantity 243 tons and increased in value per ton from $15.78 in 1914 to $39.30 in 1915. The ore, which was shipped directly to smelters, consisted of 148 tons of siliceous ore and 104 tons of copper ore.

Monte Cristo district.—The Ben Lomond Mining Co. made several shipments of siliceous ore containing gold and silver.

Sultan district.—One deep mine and 5 placers produced $1,519 in gold, 344 ounces of silver, and 41,226 pounds of copper, valued at $8,909. Sulphide copper ore was shipped from the Iowa property near Startup. Placer bullion came from small operations near Sultan.

STEVENS COUNTY.

Mine production in Stevens County, Wash., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	11	24,536	$11,894	91,480	602,996	36,196	$144,092
1915	15	35,020	4,063	109,750	617,659	271,915	180,576
Increase or decrease, 1915		+10,484	−7,831	+18,270	+14,663	+235,719	+36,484

There was increase in ore mined and in all metals produced except gold, which decreased slightly. The total value of the output increased $36,484. Twelve deep mines produced 35,020 tons of ore, an increase of 10,484 tons. The value of the ore per ton decreased from $5.87 to $5.14. Of the ore, 31,879 tons were concentrated and made 2,277 tons of concentrates, and 3,141 tons were shipped to various smelters. The ore was separated into different kinds, as follows: 34,155 tons of copper ore, 689 tons of lead ore, and 176 tons of siliceous ore.

Bossburg district.—Several hundred tons of crude sulphide lead ore were shipped from the Bonanza property, near Bossburg.

Chewelah district.—From 1901 to the end of 1915 the district has produced 94,901 tons of ore, $58,858 in gold, 637,826 ounces of silver, 3,372,818 pounds of copper, and 223,139 pounds of lead, valued at $961,822. Crude ore valued per ton at $22.11 and concentrates at $48.55 were shipped from the United Copper mine, one of the important mines of the State. According to the report[1] of the company the property produced 8.08 ounces of gold, 29,947 ounces of silver, and 181,351 pounds of copper from crude ore, and 73,248 ounces of silver and 469,644 pounds of copper from concentrates. Smelter returns from both products were $117,269. The mine is opened by a 4,220-foot tunnel to a depth of 1,000 feet, and the ore is chalcopyrite and gray copper.

As a result of experimental work, a great amount of building up and tearing down of trial equipment, of installing this and that device, and then cutting it out again was necessary, all of which has involved a great amount of expense, but could not be avoided. This has been the experience with all properties where the oil flotation system has been installed, but the additional savings have in all cases fully warranted the added expense. * * *

When the oil flotation process had shown that a saving of 80 per cent could be effected with the United Copper ores your management considered that the time had come when the mill capacity should be very largely increased. The 24 stamps then in operation were crushing the ore sufficiently fine for the oil flotation system by using the slime tables in connection, of which three were already in operation. Hence it was decided to add 50 stamps more, which was

[1] United Copper Co. Tenth Ann. Rept., for year ending Dec. 31, 1915.

done during the summer months. The plant now consists of 74 stamps housed in a good building, with a daily capacity of 250 tons when the electric power supply is sufficient for full operations.

The power question has been one of serious trouble and disappointment to our company during the past year. According to our contract we were to have a minimum of 700 horsepower by July, but the Stevens County Power & Light Co. did not get their new equipment installed at that time, and of course were not able to furnish any such power as called for, or even half of it, during the hot summer months. Since July we have been badly handicapped in our operations by the lack of power; everything possible has been done to assist the Power Co. in hastening the installation of additional equipment at their power plant, but this work is not completed at this time.

On account of this failure of the power supply our operations during the year have been very much reduced.

The Copper King mine, which has considerable development, was not operated, and at the middle of the year was sold by order of the court. Development was continued at the Security, Hecla, and Independence Keystone properties. The Hecla, 3½ miles northeast of Chewelah, is said to have 400 tons of copper ore on the dump. A good description[1] of this district, as well as of the progress in other regions of the State, was published in the early part of 1916.

Columbia River district.—From points along Columbia River, near Hunters, Gifford, and Rose Lake, placer gold valued at $580 and 6 ounces of silver was marketed.

Colville district.—The Old Dominion mine, which has been closed for 18 years, was reopened in April, 1915, by the Dominion Silver Lead Mining Co. Several shipments of lead sulphide and siliceous ore were made before the property was closed by litigation in December, 1915.

Kettle Falls district.—Ore having good gold and silver contents was shipped from the Ben Venue and Sunday properties.

Northport district.—Small shipments from various properties totaled 64 tons of ore, containing $14 in gold, 593 ounces of silver, 265 pounds of copper, and 39,282 pounds of lead, in all valued at $2,207. The Great Eastern and Last Chance properties were taken over by the Norman Mines Co. in 1915. The property is 6 miles southeast of Northport, on Deep Creek. The property formerly produced considerable lead ore, but it will ship a large quantity of zinc ore, both carbonate and sulphide, in 1916. A discovery of high-grade galena was made at the Electric Point property, 18 miles east of Northport. No ore was marketed, but the mine will be a shipper in 1916.

The town of Northport has been rejuvenated by the sale of the old Northport smelter to the Day Bros., of Wallace, Idaho. In November 240 men were said to be employed in constructing a new and substantial lead plant. Although this plant is being built for the special purpose of treating ore from the Hercules and Tamarack & Custer properties in Idaho, it will also treat custom ore, and will be a great stimulus to the mines around Northport. The equipment is given as follows in the current Survey report on lead:[2]

Two 250-ton lead furnaces, 42 by 192 inches in size, with an 18-foot smelting column, were added and blown in early in March, 1916, and the construction of a third lead furnace was begun. Three of the six copper furnaces of the old plant were renovated and will eventually be operated. Four Dwight & Lloyd

[1] Armstrong, L. K., Washington, 1915: Min. World, Feb. 5, 1916, p. 317.
[2] Siebenthal, C. E., U. S. Geol. Survey Mineral Resources, 1915, pt. 1, p. 194, 1916.

sintering machines will roast the concentrates received at the smelter. Furnace and roaster gases will be treated by the Cottrell fume precipitation process. The lead bullion produced will be treated at the affiliated refinery of the Pennsylvania Smelting Co., at Carnegie, near Pittsburgh, Pa.

Orient district.—A small tonnage of siliceous gold ore came from the Beecher property, near Orient. Development of gold ore was continued on the Interstate claims by the Vulcan Mining Co.

WHATCOM COUNTY.

Two deep mines and 2 placers produced 995 tons of ore, $12,520 in gold, and 50 ounces of silver, in all valued at $12,545. The placer output was valued at $489 for the gold and the bullion contained 8 ounces of silver. All of the ore was siliceous, was treated in gold and silver mills by the amalgamation process, and had a total value of $12,052, or $12.11 per ton.

Mount Baker district.—Most of the gold credited to the county came from the operation of the 24-ton plant at the Boundary Red Mountain property. Some bullion was also produced at the Boundary Gold property in a 5-stamp mill. The company was installing a 50-ton Lane mill and has electrified the entire plant. There was no production from the Great Excelsior property, but a 20-stamp cyanide plant was erected during 1915.

Slate Creek district.—Operators in the vicinity of Bellingham reported a small placer output.

PUBLICATIONS.

The publications of the United States Geological Survey on the metalliferous resources in Washington were given in a list[1] published in the report for 1914.

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 654, 1915.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN MONTANA.

(MINES REPORT.)

By V. C. Heikes.

PRODUCTION.

GENERAL STATEMENT.

Mines in Montana produced during the calendar year 1915 gold, silver, copper, lead, and zinc valued at $82,912,254. This was the value of the output made by 643 producers. In 1914 there were 505 producers, and the output was valued at $47,849,747. The increase of nearly 74 per cent in value in 1915 was mainly due to the increased output and higher price of copper and zinc. Silver Bow County, which includes the Butte or Summit Valley district, produced about 20 per cent of the gold, nearly 87 per cent of the silver, 99.5 per cent of the copper, nearly 58 per cent of the lead, 99.7 per cent of the zinc, and more than 94 per cent of the total value of the product from deep mines.

Mine production of metals in Montana in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	505	5,128,956	$4,117,911	12,016,460	233,229,640	9,656,008	111,580,544	$47,849,747
1915	643	6,129,924	5,004,195	14,378,437	267,231,014	13,756,356	187,146,895	82,912,254
Increase, 1915		1,000,968	886,284	2,361,977	34,001,374	4,100,348	75,566,351	35,062,507

[a] Includes placer production.

The total quantity of ore sold or treated was 1,000,968 tons more than in 1914, and the total average value per ton increased from $9.14 in 1914 to $13.37 in 1915. The average value per ton of the gold and silver contained in this ore decreased from $1.91 to $1.85. Mines in Silver Bow County are credited with the largest output of ore, of which 4,860,110 tons, or more than 87 per cent, was copper

ore; 522,300 tons lead-zinc ore; 13,124 tons dry or siliceous ore; 26 tons lead ore; and 178,545 tons zinc ore.

The State output of dry or siliceous ore was 493,500 tons, of which 466,818 tons were classified as gold ore, 25,657 tons as gold and silver ore, and 1,025 tons as silver ore. The largest part, or 315,040 tons, of dry or siliceous ore, together with 15,100 tons of old tailings, was treated by cyanidation, 28,504 tons were treated by amalgamation, and 134,301 tons were shipped directly to the smelters for treatment. Phillips, Deer Lodge, and Lewis and Clark counties, with 237,922 tons, 65,536 tons, and 60,122 tons of ore, respectively, were the largest producers of siliceous ore, and Fergus County followed with 49,493 tons. Oxidized iron ore amounting to 65,135 tons, some of it containing more than 20 per cent excess iron and a little gold, was mined in the Georgetown district of Deer Lodge County, and a similar ore, of lower grade, was mined near Elkhorn, in Jefferson County. Iron sulphide ore, aggregating nearly 25,000 tons, containing nearly an ounce of gold per ton and a little silver and copper, continued to be mined in Broadwater County, near Radersburg.

The output of copper ore was 4,863,378 tons, of which 4,260,776 tons were of milling grade and produced 1,472,961 tons of concentrate averaging 32 cents in gold and 4.39 ounces of silver per ton and 6.40 per cent of copper, and an average value per ton of $24.99. The copper ore of shipping grade amounted to 575,930 tons, largely sulphides, containing 26 cents in gold and 4.03 ounces of silver per ton and 5.85 per cent of copper, and an average value per ton of $22.80.

All the 13,783 tons of lead ore produced was shipped directly to the smelters and contained $5.71 in gold and 29.59 ounces of silver per ton, and 0.32 per cent of copper and 15.52 per cent of lead, and an average value per ton of $36.42. Lead concentrates were separated from lead-zinc ore, of which 572,373 tons were treated, and produced 7,107 tons of lead concentrate averaging $0.92 in gold and 40.06 ounces of silver per ton, and 0.29 per cent of copper and 37.37 per cent of lead. The average value per ton of all lead concentrates was $57.33. Zinc concentrates recovered from zinc ore and lead-zinc ore aggregated 207,280 tons, averaging 61 cents in gold and 15.45 ounces of silver per ton, and 0.75 per cent of copper, 0.90 per cent of lead, and 44.98 per cent of zinc, the total average value per ton being $123.47.

Ore and metals produced in Montana in 1915.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).
		Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	161	.....	45,919.87	7,775	.....	.....	.....
Dry or siliceous	301	493,500	155,055.51	1,635,221	896,903	22,772	52,429
Copper ore	73	4,863,378	30,840.90	8,819,772	263,044,912	.....	.....
Lead ore	112	13,783	3,809.00	407,859	87,748	4,278,280	.....
Zinc ore	4	178,573	1,492.37	734,798	1,911,190	200,399	47,112,274
Copper-lead ore	2	215	5.18	4,045	22,838	42,363	.....
Lead-zinc ore	7	580,475	4,955.10	2,768,967	1,267,423	9,212,542	139,982,192
		6,129,924	242,077.93	14,378,437	267,231,014	13,756,356	187,146,895

Ore sold or treated in Montana in 1915, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaverhead	194	283	981	.....	.....	57	1,515
Broadwater	25,699	305	155	.....	.....	.....	26,159
Cascade	437	.....	1,352	.....	.....	.....	1,789
Deer Lodge	65,536	2	.....	.....	.....	.....	65,538
Fergus	49,493	.....	31	.....	.....	.....	49,524
Gallatin	.....	.....	8	.....	.....	.....	8
Granite	13,760	1,151	1,103	.....	.....	.....	16,014
Jefferson	5,538	930	4,600	.....	41	120	11,229
Lewis and Clark	60,122	75	4,086	28	.....	.....	64,311
Lincoln	300	.....	77	.....	.....	.....	377
Madison	18,443	11	693	.....	.....	.....	19,147
Meagher	.....	13	.....	.....	.....	.....	13
Mineral	.....	346	147	.....	.....	49,998	50,491
Missoula	2,418	26	.....	.....	.....	.....	2,444
Phillips	237,922	.....	.....	.....	.....	.....	237,922
Powell	514	55	524	.....	.....	.....	1,093
Ravalli	.....	.....	.....	.....	.....	8,000	8,000
Sanders	.....	71	.....	.....	174	.....	245
Silver Bow	13,124	4,860,110	26	178,545	.....	522,300	5,574,105
	[a]493,500	4,863,378	13,783	178,573	215	580,475	6,129,924
Value per ton in gold and silver	$8.17	$1.05	$20.71	$2.26	$10.04	$2.59	$1.85

[a] Includes 466,818 tons of gold ore, 1,025 tons of gold and silver ore, and 25,657 tons of silver ore.

GOLD.

The mine production of gold in Montana increased from $4,117,911 in 1914 to $5,004,195 in 1915. Madison County is credited with the largest total output, $1,137,012, from deep and placer mines, the output of the latter amounting to $862,719, against $836,097 in 1914. The largest output of gold from deep mines came from Deer Lodge and Silver Bow counties, followed by Lewis and Clark, Fergus, and Phillips counties. At amalgamation and cyanidation plants $1,190,934 in gold was produced, or an average recovery of $3.32 per ton of ore and tailings treated. Ore treated at concentration mills produced concentrates containing $687,630 in gold, or 41 cents per ton. The crude ore shipped to smelters contained $2,173,743 in gold, or an average per ton of $3. Placer gold was produced in largest quantity in Madison County, chiefly the output of one company operating four dredges in Alder Gulch, which handled in 1915 about 6,000,000 cubic yards of gravel.

Mine production of gold in Montana in 1915, in fine ounces.

County.	Placers.	Deep mines.						Total.
		Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	
Beaverhead	33.09	398.79	0.18	393.41				825.47
Broadwater	278.25	19,810.16	20.90	153.48				20,262.79
Cascade	7.06	512.85		72.59				592.50
Deer Lodge	14.90	42,161.50	.02					42,176.42
Fergus		22,865.10		6.89				22,871.99
Gallatin	2.37							2.37
Granite	331.56	5,074.66	151.30	25.49				5,583.01
Jefferson	61.29	2,640.22	143.87	710.35			21.70	3,577.43
Lewis and Clark	455.79	25,307.14	1.98	482.49				26,247.40
Lincoln	122.25	164.98		61.99				349.22
Madison	41,734.03	11,816.70	29.96	1,422.27				55,002.96
Meagher	10.88							10.88
Mineral	599.32		37.39					636.71
Missoula	209.03	527.73	.14					736.90
Park	144.50							114.50
Phillips	.58	20,960.50						20,961.08
Powell	904.23	592.74	1.09	475.69				1,973.75
Ravalli	928.32						25.39	953.71
Sanders	30.57		7.54			5.18		43.29
Silver Bow	76.87	2,222.44	30,446.53	4.35	1,492.37		4,908.01	39,150.57
Toole	4.98							4.98
	45,919.87	[a]155,055.51	30,840.90	3,809.00	1,492.37	5.18	4,955.10	242,077.93

[a] Includes 150,169.29 ounces from gold ore, 125.64 ounces from gold and silver ore, and 4,760.58 ounces from silver ore.

SILVER.

Montana mines produced 14,378,437 ounces of silver, valued at $7,289,868, in 1915. The quantity produced was nearly 20 per cent greater than in 1914. From copper ore 8,819,772 ounces of silver was produced, an average of 1.81 ounces per ton, and the ore mined in Silver Bow County was responsible for the largest increase in 1915. Phillips County—the Little Rockies district—had the next highest increase in silver, which was recovered from siliceous ores. Cyanidation and amalgamation mills yielded precipitates and bullion containing 313,784 ounces of silver, concentration mills produced concentrates containing 9,991,826 ounces, and crude ore shipped to smelters contained 4,031,254 ounces.

Mine production of silver in Montana in 1915, in fine ounces.

County.	Placers.	Deep mines.						Total.
		Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	
Beaverhead	6	4,772	179	60,334			442	65,733
Broadwater	43	11,184	1,104	5,600				17,931
Cascade	2	66,623		87,863				154,488
Deer Lodge	2	37,778	596					38,376
Fergus		3,838		473				4,311
Granite	77	802,763	1,202	57,790				861,832
Jefferson	13	11,304	6,318	73,451		879	1,476	93,441
Lewis and Clark	133	74,833	329	84,250				159,545
Lincoln	11	29		4,022				4,062
Madison	7,240	80,305	79	11,062				98,686
Meagher	2		3					5
Mineral	24		127	8,829			114,265	123,245
Missoula	9	185	48					242
Park	19							19
Phillips		246,336						246,336
Powell	111	5,490	80	13,158				18,839
Ravalli	63						3,396	3,459
Sanders	5		107			3,166		3,278
Silver Bow	15	289,781	8,809,600	1,027	734,798		2,649,388	12,484,609
	7,775	[a] 1,635,221	8,819,772	407,859	734,798	4,045	2,768,967	14,378,437

[a] Includes 464,292 ounces from gold ore, 5,315 ounces from gold and silver ore, and 1,165,614 ounces from silver ore.

COPPER.

Copper from Montana ores sold or treated increased 34,001,374 pounds in quantity and $15,745,885 in value in 1915. Silver Bow County, or practically the Butte district, contributed all the copper except 1,224,545 pounds. Mines in Broadwater County produced the next largest quantity, 675,937 pounds, followed in order by Deer Lodge, Beaverhead, and Granite counties. Crude ore of various kinds smelted in 1915 contained 68,443,491 pounds of copper, an average of 4.72 per cent. The sulphide copper ore of smelting grade predominated and contained 66,895,108 pounds, an average of 5.88 per cent, and the oxidized copper ores contained 546,385 pounds, or 3.59 per cent. Copper precipitates produced from mine waters and the washings from old tailings contained 5,645,441 pounds, against 5,216,782 pounds in 1914. Concentrates shipped to smelters contained 192,000,815 pounds, the bulk of which was from copper concentrates, which averaged 5.68 per cent. The output of copper from the Butte or Summit Valley district increased from 232,175,254 pounds in 1914 to 265,999,832 pounds in 1915.

Mine production of copper in Montana in 1915, in pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaverhead	2,248	50,382	73,358	.....	.....	.....	125,988
Broadwater	627,186	48,751	.....	.....	.....	.....	675,937
Cascade	795	.....	3,570	.....	.....	.....	4,365
Deer Lodge	139,106	127	.....	.....	.....	.....	139,233
Fergus	509	.....	788	.....	.....	.....	1,297
Granite	6,445	75,876	.....	.....	.....	.....	82,321
Jefferson	12,682	53,633	1,417	.....	2,218	677	70,627
Lewis and Clark	810	14,408	1,689	.....	.....	.....	16,907
Madison	10,712	587	6,752	.....	.....	.....	18,051
Meagher	.....	3,430	.....	.....	.....	.....	3,430
Mineral	.....	36,502	.....	.....	.....	.....	36,502
Missoula	938	2,182	.....	.....	.....	.....	3,120
Powell	748	8,412	.....	.....	.....	.....	9,160
Sanders	.....	16,987	.....	.....	20,620	.....	37,607
Silver Bow	94,724	262,733,635	174	1,911,190	.....	1,266,746	266,006,469
	[a] 896,903	263,044,912	87,748	1,911,190	22,838	1,267,423	267,231,014

[a] Includes 790,345 pounds from gold ore, 6,287 pounds from gold and silver ore, and 100,271 pounds from silver ore.

LEAD.

The mine production of lead in Montana was 13,756,356 pounds, valued at $646,549, in 1915, against 9,656,008 pounds, valued at $376,584, in 1914. Of this output nearly 58 per cent was derived from mines in Silver Bow County, which produced 7,936,121 pounds, against 5,386,356 pounds in 1914. This increase was due largely to the output of lead in lead-zinc ores, which were concentrated. The next largest output of lead, or 1,562,330 pounds, came from the mines in Lewis and Clark County, followed by Mineral County with 1,528,661 pounds. Crude ore of all kinds shipped to the smelters contained about 32 per cent of the total lead, or 4,367,712 pounds, and the remainder, 9,388,644 pounds, was contained in concentrates. Lead ore shipped to smelters contained 4,278,280 pounds of lead, an average of more than 15 per cent, and the lead concentrates contained 5,512,802 pounds, an average of more than 37 per cent. The zinc con-

centrate in which lead was paid for contained 3,742,745 pounds. This is practically all from two mines at Butte.

Mine production of lead in Montana in 1915, in dry pounds.

County.	Dry or siliceous ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Total.
Beaverhead	9,962	440,693	.....	.....	16,989	467,644
Broadwater	2,150	78,271	.....	.....	.....	80,421
Cascade	.....	526,751	.....	.....	.....	526,751
Fergus	.....	18,713	.....	.....	.....	18,713
Gallatin	.....	8,880	.....	.....	.....	8,880
Granite	.....	134,681	.....	.....	.....	134,681
Jefferson	978	943,931	.....	8,052	22,891	975,852
Lewis and Clark	350	1,561,980	.....	.....	.....	1,562,330
Lincoln	.....	53,305	.....	.....	.....	53,305
Madison	9,332	274,121	.....	.....	.....	283,453
Mineral	.....	93,468	.....	.....	1,435,193	1,528,661
Powell	.....	139,188	.....	.....	.....	139,188
Ravalli	.....	.....	.....	.....	6,045	6,045
Sanders	.....	.....	.....	34,311	.....	34,311
Silver Bow	.....	4,298	200,399	.....	7,731,424	7,936,121
	[a] 22,772	4,278,280	200,399	42,363	9,212,542	13,756,356

[a] Includes 20,093 pounds from gold ore, 221 pounds from gold and silver ore, and 2,458 pounds from silver ore.

ZINC.

The mine production of zinc (calculated as spelter) in Montana was 187,146,895 pounds, valued at $23,206,215, in 1915, against 111,580,544 pounds, valued at $5,690,608, in 1914. The bulk of the zinc output was from Silver Bow County, and smaller quantities were from Mineral, Ravalli, Beaverhead, Jefferson, and Lewis and Clark counties. The largest quantity of zinc was produced from the Butte & Superior mine, at Butte, and amounted to 163,956,791 pounds gross, in concentrates having an average zinc content of 57.616 per cent. All of this concentrate and that of the Elm Orlu property is shipped to eastern refineries. The Anaconda Copper Co. started at Washoe the operation of an electrolytic zinc plant of comparatively small proportions at present, and has under construction a plant that is expected to produce 100 tons of spelter a day. In addition, an electrolytic plant designed to produce 35,000 tons of spelter per annum was under construction at Great Falls, Mont., at the close of 1915.

Mine production of zinc in Montana in 1915, in pounds.

County.	Dry or siliceous ore.	Zinc ore.	Lead-zinc ore.	Total.
Beaverhead	.....	.....	33,136	33,136
Jefferson	.....	.....	19,796	19,796
Lewis and Clark	.....	13,600	.....	13,600
Mineral	.....	.....	432,283	432,283
Ravalli	.....	.....	133,705	133,705
Silver Bow	52,429	47,098,674	139,363,272	186,514,375
	52,429	47,112,274	139,982,192	187,146,895

MINING INDUSTRY.

Montana mines were very active and mining profits were greatly increased by the increase in prices of metals during the greater part of 1915. The record production of silver and zinc and the large out-

put of copper are the results of years of preparation, during which many mining interests have been consolidated. New mining machinery, operated by electricity instead of steam, has been installed, and several new metallurgical methods have been successfully tested, all of which will continue to lower the cost and increase the output of metal produced in the State. Labor was paid $3.50 a day at the beginning of the year at most of the mines on a five-day a week schedule. At the end of 1915 the scale was $4 a day with a six-day a week schedule. The monthly pay roll of one company at Butte was said to have been $400,000 in January, 1915, and $1,150,000 in December. Approximately 14,000 men were employed in the Butte district, and nearly every mining property in the district was worked at capacity. The Anaconda Co. in January operated only 12 of its 22 shafts, employed 5,200 men, and had a daily ore output of 7,500 tons; in December it employed 10,500 men, operated all of the 22 shafts, and had a daily ore output of 15,000 tons. Power development has been of great importance to the mining industry of the Butte district. The extensive hydroelectric developments at Volta, near Great Falls, on Missouri River, and at Thompson Falls, on Clark Fork of Columbia River, have been completed. The former has a capacity of 80,000 horsepower and the latter of 40,000 horsepower. Electrification of the Chicago, Milwaukee & St. Paul Railway in Montana was about complete at the close of 1915.

METALLURGIC INDUSTRY.

Altogether 53 milling plants of various kinds were operated in Montana during part or the whole of the year 1915, some of them only for short periods. Nineteen plants used the amalgamation process; 2 used amalgamation and concentration; 3 used amalgamation and cyanidation; 14 were cyanidation mills; 11 were concentration mills, of which 6 used oil-flotation equipment; 1 used concentration and cyanidation; 1 was a copper leaching plant; and 2 were copper precipitating plants that extracted copper from mine waters. There were several additional precipitating plants operated by lessees, whose output was included with that of the company from which they leased. Of the 343,544 tons of ore treated at gold and silver mills, 28,504 tons were treated by amalgamation and yielded 5,198.99 ounces of gold and 2,020 ounces of silver, or an average recovery of $3.77 in gold and 0.07 ounce of silver per ton. The ore treated by cyanidation aggregated 315,040 tons, which, with 15,100 tons of old tailings, yielded 52,413.44 ounces of gold and 311,764 ounces of silver, or an average recovery per ton for ore and tailings of $3.28 in gold and 0.94 ounce of silver. The total value of the bullion recovered from ore and old tailings by both amalgamation and cyanidation was $1,300,022, as against the output in 1914 valued at $891,666. During 1915 there were 371 pounds of mercury, 1,003 pounds of potassium cyanide, and 162,377 pounds of sodium cyanide consumed in gold and silver mills. This represented 0.051 pound of mercury per ounce of gold and silver bullion and 0.013 pound per ton of ore treated. The consumption of cyanide was 0.449 pound per ounce of gold and silver bullion and 0.494 pound per ton of ore and tailings treated.

Gold and silver produced at mills in Montana in 1915.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Broadwater	[a] 84	410.61	115			$8,546
Deer Lodge	330	1.81	1	3.42	7	112
Fergus	49,213			21,685.24	2,720	449,653
Granite	176	133.94	27	11.61	33	3,039
Jefferson	5	3.00	1			63
Lewis and Clark	[b] 48,757	2,158.76	1,016	[c] 8,448.14	[c] 24,752	232,328
Lincoln	300	165.00	29			3,426
Madison	[d] 15,399	2,097.35	806	961.28	37,895	82,848
Missoula	1,235	133.00	4	[e] 342.25	[e] 21	9,837
Phillips	227,922			[f] 20,960.50	[f] 246,336	558,184
Powell	58	54.66	15			1,138
Silver Bow	65	40.86	6			848
	343,544	5,198.99	2,020	52,412.44	311,764	1,350,022

[a] Also yielded 1 ton of concentrates.
[b] Also yielded 40 tons of concentrates.
[c] Includes bullion from 3,975 tons of old tailings.
[d] Also yielded 1,039 tons of concentrates.
[e] Includes bullion from 1,125 tons of old tailings.
[f] Includes bullion from 10,000 tons of old tailings.

Mills in Montana equipped for the concentration of low-grade ore treated 4,987,016 tons, or more than 81 per cent of the total ore mined. The concentrates produced and smelted amounted to 1,689,425 tons, containing 33,264.10 ounces of gold, 9,991,826 ounces of silver, 192,000,815 pounds of copper, 9,388,644 pounds of lead, and 186,858,603 pounds of zinc, valued in all at $62,965,362, or an average value of $37.27 per ton. During 1915 the Washoe plant of the Anaconda Copper Co. was completely overhauled, much of it reconstructed, and many additions made. The concentration plant was remodeled and rebuilt at a cost of nearly $2,000,000, and a new oil-flotation plant was installed. An ore-roasting plant was constructed at a cost of $1,000,000. A new reverberatory plant was completed at a cost of more than $500,000. The converter plant was remodeled and a new reverberatory furnace added to it at a cost of $500,000. The power substation was enlarged to three times its former capacity and equipped at an expense of $200,000. The new sulphuric-acid plant was built and equipped at a cost of $500,000. A zinc experimental plant was constructed and put into operation, and a new building for the leaching plant was equipped. The estimated cost of all the improvements at the Washoe smelter for the year was about $6,000,000. At Great Falls the most notable improvement was the erection of the new electrolytic copper refinery, with a capacity of 15,000,000 pounds of refined copper per month, at a cost exceeding $200,000. The plant will handle the copper anodes from the Anaconda plant and will furnish the western market with copper for commercial purposes.

The following tables give the quantity of material shipped from the concentration mills and of crude ore shipped to the smelters, with the metal produced, by counties, in 1915:

Mine production of metals from Montana concentrates in 1915.

By counties.

	Ore to concentrating mills.	Concentrates produced.						Total value of concentrates.
		Quantity.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Broadwater	.....	1	24.00	134	.....	.....	.....	$564
Granite	18	6	6.05	1	46	.....	.....	134
Jefferson	591	220	25.38	2,569	23,532	22,891	19,796	9,476
Lewis and Clark	69	63	69.18	834	.....	.....	.....	1,853
Madison	403	1,164	3,308.87	21,242	3,860	.....	.....	79,846
Mineral	50,161	2,425	.52	114,332	16,279	1,427,885	405,508	178,219
Ravalli	.....	192	25.39	3,396	.....	6,045	133,705	19,110
Silver Bow	4,935,774	1,685,354	29,804.71	9,849,318	191,957,098	7,931,823	186,299,594	62,676,160
	4,987,016	1,689,425	33,264.10	9,991,826	192,000,815	9,388,644	186,858,603	62,965,362

By kinds of concentrates.

Dry or siliceous	.....	1,235	3,408.51	22,212	3,906	.....	.....	$82,406
Copper	.....	1,472,961	23,408.14	6,466,291	188,818,296	.....	.....	36,805,501
Lead	.....	7,359	332.05	290,517	49,526	5,512,802	.....	421,925
Zinc	.....	207,280	6,115.40	3,202,965	3,129,087	3,742,745	186,453,095	25,594,003
Lead-zinc	.....	590	.....	9,841	.....	133,097	405,508	61,527

Mine production of metals from Montana crude ore shipped to smelters in 1915.

By counties.

	Crude ore to smelter.						Total value.
	Quantity.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Beaverhead	1,515	792.38	65,727	125,988	467,644	33,136	$97,840
Broadwater	26,075	19,549.93	17,639	675,937	80,421	.....	535,144
Cascade	1,789	585.44	154,486	4,365	526,751	.....	115,947
Deer Lodge	65,163	42,155.57	38,072	137,648	.....	.....	914,825
Fergus	311	1,186.75	1,591	1,297	18,713	.....	26,446
Gallatin	8	.....	.....	.....	8,880	.....	417
Granite	15,820	5,099.80	861,694	82,275	134,681	.....	563,029
Jefferson	10,633	3,487.76	90,858	47,095	952,961	.....	171,195
Lewis and Clark	11,510	15,115.53	132,810	16,907	1,562,330	13,600	457,875
Lincoln	77	61.97	4,022	.....	53,305	.....	5,826
Madison	3,345	6,901.43	31,503	14,191	283,453	.....	174,442
Meagher	13	.....	3	3,430	.....	.....	601
Mineral	330	36.87	8,889	20,223	100,776	26,775	16,864
Missoula	84	52.62	208	3,120	.....	.....	1,739
Powell	1,035	1,014.86	18,713	9,160	139,188	.....	38,612
Sanders	245	12.72	3,273	37,607	34,311	.....	10,117
Silver Bow	586,806	9,101.13	2,601,766	67,264,248	4,298	214,781	13,305,311
	724,759	105,154.76	4,031,254	68,443,491	4,367,712	288,292	16,436,230

By kinds of ore.

Dry or siliceous	134,301	94,034.85	1,298,931	891,412	22,772	52,429	$2,765,999
Copper	575,930	7,305.76	2,319,977	67,441,493	.....	.....	13,129,513
Lead	13,783	3,809.00	407,859	87,748	4,278,280	.....	501,959
Zinc	428	.....	.....	.....	.....	175,952	21,818
Copper-lead	215	5.20	4,045	22,838	42,363	.....	8,146
Lead-zinc	102	.....	442	.....	24,297	59,911	8,795

PRODUCTION BY COUNTIES.

GENERAL FEATURES.

A table follows showing the total of the State output by counties in 1915, and the mine production of each metal, with its total value; also a table showing production of ore and average value per ton by counties in 1914 and 1915, a table of the statistics of placer mines, and a review of the mining industry for each county and each producing mining district.

Mine production of metals in Montana in 1915.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total value.	Quantity.	Value.
	Quantity.	Value.	Quantity.	Value.			
	Fine ounces.		*Fine ounces.*			*Fine ounces.*	
Beaverhead	33.09	$684	792.38	$16,380	$17,064	65,733	$33,327
Broadwater	278.25	5,752	19,984.54	413,117	418,869	17,931	9,091
Cascade	7.06	146	585.44	12,102	12,248	154,488	78,325
Deer Lodge	14.90	308	42,161.52	871,556	871,864	38,376	19,457
Fergus			22,871.99	472,806	472,806	4,311	2,186
Gallatin	2.37	49			49		
Granite	331.56	6,854	5,251.45	108,557	115,411	861,832	436,949
Jefferson	61.29	1,267	3,516.14	72,685	73,952	93,441	47,375
Lewis and Clark	455.79	9,422	25,791.61	533,160	542,582	159,545	80,889
Lincoln	122.25	2,527	226.97	4,692	7,219	4,062	2,059
Madison	41,734.03	862,719	13,268.93	274,293	1,137,012	98,686	50,034
Meagher	10.88	225			225	5	2
Mineral	599.32	12,389	37.39	773	13,162	123,245	62,485
Missoula	209.03	4,321	527.87	10,912	15,233	242	123
Park	114.50	2,367			2,367	19	10
Phillips	.58	12	20,960.50	433,292	433,304	246,336	124,892
Powell	904.23	18,692	1,069.52	22,109	40,801	18,839	9,551
Ravalli	928.32	19,190	25.39	525	19,715	3,459	1,754
Sanders	30.57	632	12.72	263	895	3,278	1,662
Silver Bow	76.87	1,589	39,073.70	807,725	809,314	12,484,609	6,329,697
Toole	4.98	103			103		
	45,919.87	949,248	196,158.06	4,054,947	5,004,195	14,378,437	7,289,868

County.	Copper.		Lead.		Zinc (spelter).		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Beaverhead	125,988	$22,048	467,644	$21,979	33,136	$4,109	$98,527
Broadwater	675,937	118,289	80,421	3,780			550,029
Cascade	4,365	764	526,751	24,757			116,094
Deer Lodge	139,233	24,366					915,687
Fergus	1,297	227	18,713	880			476,099
Gallatin			8,880	417			466
Granite	82,321	14,406	134,681	6,330			573,096
Jefferson	70,627	12,360	975,852	45,865	19,796	2,455	182,007
Lewis and Clark	16,907	2,958	1,562,330	73,430	13,600	1,686	701,545
Lincoln			53,305	2,505			11,783
Madison	18,051	3,159	283,453	13,322			1,203,527
Meagher	3,430	600					827
Mineral	36,502	6,388	1,528,661	71,847	432,283	53,603	207,485
Missoula	3,120	546					15,902
Park							2,377
Phillips							558,196
Powell	9,160	1,603	139,188	6,542			58,497
Ravalli			6,045	284	133,705	16,579	38,332
Sanders	37,607	6,581	34,311	1,613			10,751
Silver Bow	266,006,469	46,551,132	7,936,121	372,998	186,514,375	23,127,783	77,190,924
Toole							103
	267,231,014	46,765,427	13,756,356	646,549	187,146,895	23,206,215	82,912,254

Ore sold or treated, mines producing, and average value per ton of ores in Montana in 1914 and 1915.

County.	Ore sold or treated, 1915.		Number of deep mines producing.		Average value per ton.[a]		Average value per ton in gold and silver.[a]	
	Quantity.	Increase or decrease.	1914	1915	1914	1915	1914	1915
	Short tons.	*Short tons.*						
Beaverhead	1,515	— 15,797	10	13	$4.90	$64.58	$3.28	$32.81
Broadwater	26,159	— 1,046	19	28	20.65	20.81	18.23	16.14
Cascade	1,789	— 5,503	12	14	20.75	64.81	12.21	50.55
Deer Lodge	65,538	+ 9,417	8	12	12.69	13.96	12.31	13.60
Fergus	49,524	— 3,301	7	7	9.96	9.61	9.96	9.59
Gallatin	8	+ 8	.....	1	.....	52.13	.....	.....
Granite	16,014	+ 617	32	33	31.78	35.36	30.68	34.06
Jefferson	11,229	— 4,768	49	65	16.90	16.10	9.10	10.69
Lewis and Clark	64,311	+ 38,963	42	82	7.05	10.76	5.73	9.55
Lincoln	377	+ 377	.....	2	.....	24.54	.....	17.89
Madison	19,147	— 8,065	90	115	14.29	17.61	13.90	16.75
Meagher	13	— 13	2	1	37.81	46.23	.08	.08
Mineral	50,491	+ 50,491	.....	6	.....	3.86	.....	1.23
Missoula	2,444	— 9,414	7	6	5.44	4.74	3.28	4.51
Phillips	237,922	+ 116,763	3	3	2.09	2.35	2.09	2.35
Powell	1,093	— 761	13	32	37.34	36.37	30.00	28.91
Ravalli	8,000	+ 7,961	2	1	28.00	2.39	17.69	.28
Sanders	245	+ 123	1	3	55.33	41.29	16.64	7.85
Silver Bow	5,574,105	+ 824,916	61	58	9.08	13.85	1.36	1.28
	6,129,924	+1,000,968	358	482	9.14	13.37	1.91	1.85

[a] Placer product excluded.

Number of producing placer mines and production in Montana in 1914 and 1915.

County.	1914					
	Hydraulic, dry, and sluicing.	Dredging.	Drift.	Gold.	Silver.	Total value.
					Fine ounces.	
Beaverhead	7	.....	.....	$2,080	12	$2,087
Broadwater	10	.....	.....	4,060	28	4,076
Cascade	.....	.....	.....	.....	.....	.....
Deer Lodge	2	.....	.....	626	3	628
Gallatin	.....	.....	.....	.....	.....	.....
Granite	10	.....	.....	29,739	437	29,981
Jefferson	11	.....	.....	3,095	29	3,111
Lewis and Clark	30	.....	1	8,310	80	8,354
Lincoln	1	.....	.....	37	.....	37
Madison	12	1	.....	836,097	6,149	839,497
Meagher	2	.....	.....	186	2	187
Mineral	.....	.....	.....	.....	.....	.....
Missoula	19	1	.....	21,154	39	21,176
Park	5	.....	.....	888	4	890
Phillips	.....	.....	.....	.....	.....	.....
Powell	21	.....	2	25,302	183	25,403
Ravalli	3	.....	.....	6,260	20	6,271
Sanders	3	.....	.....	794	4	796
Silver Bow	6	.....	.....	3,589	51	3,617
Toole	.....	.....	.....	.....	.....	.....
	142	2	3	942,217	7,041	946,111

Number of producing placer mines and production in Montana, etc.—Continued.

County.	1915					
	Hydraulic, dry, and sluicing.	Dredging.	Drift.	Gold.	Silver.	Total value.
					Fine ounces.	
Beaverhead	5			$684	6	$687
Broadwater	11		1	5,752	43	5,774
Cascade	1			146	2	147
Deer Lodge	2			308	2	309
Gallatin	1			49		49
Granite	13		1	6,854	77	6,893
Jefferson	9			1,267	13	1,274
Lewis and Clark	34			9,422	133	9,489
Lincoln	6			2,527	11	2,533
Madison	10	1		862,719	7,240	866,390
Meagher	2			225	2	226
Mineral	12	1		12,389	24	12,401
Missoula	12			4,321	9	4,325
Park	3		2	2,367	19	2,377
Phillips	1			12		12
Powell	19		1	18,692	111	18,748
Ravalli	4			19,190	63	19,222
Sanders	3			632	5	634
Silver Bow	5			1,589	15	1,597
Toole	1			103		103
	154	2	5	949,248	7,775	953,190

BEAVERHEAD COUNTY.

Mine production in Beaverhead County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	17	17,312	$9,616	88,918	58,949	521,826		$86,979
1915	18	1,515	17,064	65,733	125,988	467,644	33,136	98,527
Increase or decrease, 1915		−15,797	+7,448	−23,185	+67,039	−54,182	+33,136	+11,548

[a] Includes placer production.

The output by 13 deep-mine operators was 15,797 tons less than that of 10 deep-mine operators in 1914. The total average value per ton increased from $4.90 in 1914 to $64.58 in 1915, and the gold and silver value from $3.28 to $32.81 per ton. The producers in 1914 mined ore largely of milling grade; all the ore mined in 1915 was of shipping grade and contained $16,380 in gold, 65,727 ounces of silver, 125,988 pounds of copper, 467,644 pounds of lead, and 33,136 pounds of zinc, valued in all at $97,840, or an average value per ton of $64.58. The largest part, or 981 tons, was lead ore, 283 tons was copper ore, 194 tons was dry or siliceous ore, and 57 tons was lead-zinc ore. Placer bullion produced contained $684 in gold and 6 ounces of silver, against a yield of $2,080 in gold and 12 ounces of silver in 1914.

Argenta district.—Ore containing gold, silver, copper, and lead of shipping grade aggregating 338 tons, with an average value per ton

of $40.74, was shipped by 2 producers. The Tilden mine was the principal producer, and a small production was made by the Head property.

Bald Mountain district.—The placer claims on the West Fork of Dies Creek produced some gold during the development of the property.

Bannock district.—Great activity prevailed in this district in 1915 in preparing some of the old properties for production on a larger scale and for the treatment of ores by modern methods. Very little ore was shipped; some placer bullion was produced.

Beaverhead or Bloody Dick district.—Three deep mines produced 23 tons of ore containing principally silver and lead, with a little copper. Some silver ore, containing a little lead, was shipped from the Sunshine property. The placer output reported by one producer was not important.

Big Hole district.—Placer bullion sold to dealers from various small workings amounted to $265 in gold and 2 ounces of silver, against $612 in gold and 7 ounces of silver in 1914.

Blue Wing district.—One property produced some silver ore, probably shipped by a lessee.

Bryant district.—The milling plant in the district was idle in 1915, and all of the ore produced from one property, carrying principally lead and silver, was shipped directly to smelters. There was also a small quantity of zinc-lead sulphide ore sold to one of the smelting plants.

Jackson section.—The Saginaw property, situated near Jackson in an unorganized district, yielded considerable oxidized copper ore containing a small quantity of silver. The property is opened by an incline shaft 300 feet deep and has 350 feet of drifts.

Polaris district.—Silver ore carrying a little gold and some copper, shipped from one property by lessees, constituted the total output of the district in 1915.

Utopia district.—Oxidized ore from the waste dump of the Indian Queen property, carrying copper and silver, was shipped to the smelter.

Vipond district.—The Big Snowy and Tillie properties produced a small quantity of siliceous gold ore, which was shipped to the smelter.

BROADWATER COUNTY.

Mine production in Broadwater County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine oz.*	*Pounds.*	*Pounds.*	
1914	29	27,205	$492,119	14,200	484,977	32,252	$565,732
1915	40	26,159	418,869	17,931	675,937	80,421	550,029
Increase or decrease, 1915		−1,046	−73,250	+3,731	+190,960	+48,169	−15,703

[a] Includes placer production.

Twenty-eight deep-mine operators reported the production of 1,046 tons less than was produced by 19 operators in 1914. The total aver-

age value per ton increased slightly from $20.65 in 1914 to $20.81 in 1915, and the gold and silver value in this ore decreased from $18.23 to $16.14. The greater part of the ore, 26,075 tons, was of shipping grade. There were treated at one milling plant 84 tons of gold-silver ore, which yielded gold and silver bullion and some concentrate. The total output of the county was $418,869 in gold, 17,931 ounces of silver, 675,937 pounds of copper, and 80,421 pounds of lead, valued in all at $550,029. The yield of placer bullion amounted to $5,752 in gold and 43 ounces of silver, against $4,060 in gold and 28 ounces of silver in 1914.

Backer or Diamond City district.—After amalgamating the free gold from the sorted ore mined from the Slim Jim property, the tailing, which contained a large quantity of gold, was shipped. Placers in Confederate Gulch were operated and yielded considerable gold.

Bar Gulch section.—Placer gold from Bar Gulch, 7 miles east of York, in an unorganized district, was produced and sold to the storekeepers, who reported the output.

Beaver Creek or Winston district.—The reports received from 10 deep-mine producers showed the output of 192 tons of ore, containing $4,194 in gold, 3,322 ounces of silver, 1,143 pounds of copper, and 19,418 pounds of lead, valued in all at $6,691, or an average value per ton of $34.85. The larger part of the ore, or 132 tons, was of shipping grade. The output of 1914 amounted to 117 tons of lead ore, which averaged $48.84 per ton. The principal producers were the East Pacific, Little Olga, Joe Dandy, Edna and Noon, and Gold Bug properties. Four placer producers reported $816 in gold and 4 ounces of silver.

Cedar Plains or Radersburg district.—Seven deep-mine producers reported the output of 25,831 tons of ore. All this ore, with the exception of a few tons yielding gold and silver bullion, was shipped directly to the smelters and produced $398,433 in gold, 11,425 ounces of silver, 674,794 pounds of copper, and 2,150 pounds of lead, valued in all at $522,415, or an average value per ton of $20.22. The Keating property was the largest shipper, producing chiefly an auriferous pyritic iron ore. The Black Friday, Alaska, and Arthur Lee mines were also producers of shipping ore. Placer mines produced $781 in gold and 4 ounces of silver.

Park district.—Ten deep mines produced principally ore of shipping grade. The 121 tons sold or treated contained $2,587 in gold, 2,927 ounces of silver, and 58,853 pounds of lead, valued in all at $6,837, or an average value per ton of $56.50. From two properties bullion was recovered from a small quantity of ore treated in amalgamation mills. The principal producers of shipping ore were the Relief, Goodenough, Boomerang, and W. A. Clark properties. Placer gold from 4 producers amounted to $1,014 in gold and 8 ounces of silver. The Kalamazoo property, in the Warm Springs section, produced the largest quantity of placer gold.

CASCADE COUNTY.

Mine production in Cascade County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	12	7,292	$89,131	144,473	3,621	1,583,041	1,870	$151,341
1915	15	1,789	[a] 12,248	[a] 154,488	4,365	526,751	.....	116,094
Increase or decrease, 1915..	.....	−5,503	+3,117	+10,015	+744	−1,056,290	−1,870	−35,247

[a] Includes placer production.

Fourteen producers shipped 5,503 tons less ore in 1915 than was produced in the county by 12 operators in 1914. The total average value per ton of the ore increased from $20.75 in 1914 to $64.81 in 1915, and the gold and silver value per ton from $12.21 to $50.55. The total output of the county, including some placer gold from one mine, amounted to $12,248 in gold, 154,488 ounces of silver, 4,365 pounds of copper, and 526,751 pounds of lead, valued in all at $116,094. The greater part of the ore, or 1,352 tons, contained lead, and the remainder, 437 tons, was dry or siliceous in character.

Montana district.—The principal producer was the Barker mine, operated by lessees. The mill on the property was idle, and the lead sulphide ore produced was shipped directly to the smelter. Other producers shipped ore from the Broadwater, Big Seven, Wright & Edwards, Benton Group, London, Liberty, Queen, Ripple, and Silver Belt properties. The Anaconda Copper Co. recently leased the Queen of the Hills and the Galt mines. A large quantity of silver ore formerly came from the district, and with the increased price of silver profitable operations are expected. The Nettie, which is owned by the Anaconda Co., is said to have large deposits of rich zinc ores in addition to the silver ores, and it is expected that the mine will be ready for operation by the time the new electrolytic zinc plant at Anaconda is completed.

DEER LODGE COUNTY.

Twelve deep mine operators reported the production of 65,538 tons of ore. This is an increase in 1915 of 9,417 tons and 4 operators. The total value per ton increased from $12.69 in 1914 to $13.96 in 1915, and the gold and silver value per ton from $12.31 to $13.60. The larger part of the ore, or 65,163 tons, was a highly oxidized ore of shipping grade, containing principally gold values, chiefly valuable at the smelters for its fluxing quality. There was also a small quantity of ore yielding gold and silver bullion. The placer output amounted to $308 in gold and 2 ounces of silver, as against an output in 1914 of $626 in gold and 3 ounces of silver.

Dry Gulch section.—This region, 12 miles north of Anaconda, produced a small quantity of placer gold in 1915.

Georgetown district.—Ten deep mine producers reported the production of 65,510 tons of ore, the larger part of which was oxidized

iron ore from the Southern Cross mine, carrying gold and a small percentage of copper. Other shipments were made from the Holdfast, Oro Fino, and Short Shift properties.

FERGUS COUNTY.

Mine production in Fergus County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	7	52,825	$523,148	5,716	.....	.....	$526,309
1915	7	49,524	472,806	4,311	1,297	18,713	476,099
Increase or decrease, 1915	.....	−3,301	−50,342	−1,405	+1,297	+18,713	−50,210

[1] Includes placer production.

The output reported by 7 producers was 49,524 tons of ore, all of which, with the exception of 311 tons, was of milling grade, yielding gold and silver bullion. The ore shipped contained gold, silver, copper, and lead, and averaged $85.04 per ton.

North Moccasin district.—The Kendall and North Moccasin properties were the principal producers of ore treated by cyanidation, yielding gold and silver bullion. The North Moccasin property was operated by the Barnes King Development Co., and the Kendall mines were purchased by this company during the latter part of the year.

The North Moccasin mine[1] yielded 47,038 tons of ore in 1915, averaging $9.80 in gold and silver per ton. The percentage of gold extracted by cyanidation was 89.7 per cent, with a consumption of cyanide averaging 0.4 of a pound per ton; zinc, 0.43 pound per ton; and lime, 4.03 pounds per ton. In August an oil-fired roaster was installed. After the unoxidized ore is moderately roasted it is amenable to cyanide treatment and yields 81.3 per cent of its gold. The consumption of lime is 21.5 pounds per ton and the cyanide 1.3 pounds per ton.

The Kendall mine, taken over by the Barnes-King Development Co., was closed in 1913, having exhausted the known ore bodies at a depth of 560 feet, or about 180 feet above the North Moccasin's lowest level. The company, in its annual report, states that it is possible some ore body connecting the two mines will be found.

Warm Springs district.—The Spotted Horse property was the principal producer, yielding ore of shipping grade, containing principally gold, with a little silver and copper. The Cumberland produced some gold and silver ore.

GALLATIN COUNTY.

The output of 1 deep mine, which shipped lead ore, and of 1 placer was valued at $466.

[1] Barnes King Development Co. Ann. Rept. for year ending Dec. 31, 1915.

Pass Creek district.—A small quantity of lead ore was reported as shipped from one property during 1915.

Springhill district.—Some gold was produced from a placer in West Fork Gulch.

GRANITE COUNTY.

Mine production in Granite County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	42	15,397	$108,446	712,257	90,409	125,819	$519,256
1915	47	16,014	115,411	861,832	82,321	134,681	573,096
Increase or decrease, 1915		+617	+6,965	+149,575	−8,088	+8,862	+53,840

[a] Includes placer production.

The 33 deep-mine producers reported 617 tons more than was reported by 32 producers in 1914. The total average value per ton increased from $31.78 in 1914 to $35.36 in 1915, and the gold and silver value per ton from $30.68 to $34.06. The ore shipped contained gold, silver, copper, and lead with an average value per ton of $35.59. There were 176 tons yielding bullion treated at gold and silver mills, and a small quantity of concentrate containing gold and a little copper was recovered from ore treated at a milling plant. Fourteen placer operators reported the yield of $6,854 in gold and 77 ounces of silver, against $29,739 in gold and 437 ounces of silver from 10 placers in 1914.

Alps district.—The Rainy Day claim produced a small quantity of ore yielding gold and silver bullion in a 5-ton amalgamation mill on the property.

First Chance district.—Five deep mines yielded 889 tons of ore of shipping grade, containing $57,621 in gold, 4,693 ounces of silver, and 626 pounds of copper, valued in all at $60,110, or an average value per ton of $67.62. The Nancy Hanks property, operated by lessees and yielding a siliceous gold ore containing a little silver was the principal producer. Other producers were the Fourth of July, Lynx, and Shamrock mines. Placer gold reported by seven producers amounted to $930 in gold and 6 ounces of silver, as against an output reported in 1914 of $1,350 in gold and 6 ounces of silver. Most of the placer gold was sold to merchants and some to the United States assay office at Helena.

Flint Creek district.—The output of ore reported from 17 deep mines was 13,717 tons, containing $44,366 in gold, 853,070 ounces of silver, 4,406 pounds of copper, and 133,809 pounds of lead, valued in all at $483,933, or an average value per ton of $35.28. The output in 1914 amounted to 13,784 tons, with an average value per ton of $31.74. The greater part of the ore in 1915 was produced from the Granite Bi-Metallic, Hope, and Coyle properties. Silver-lead ore was produced from the McKay and Spawn lodes, and silver ore carrying a little copper and gold came from the Hobo group. The Pocahontas, Two Per Cent, and Trout claims were also producers. From the old

mills in the district a considerable number of flasks of quicksilver and some silver bullion were recovered. Placer mines yielded $251 in gold.

Red Lion district.—The Golden Eagle and Flint Creek properties on Flint Creek were developed during the year. Some development work was also done on the Red Lion group, and some gold ore was produced.

Rock Creek district.—The placers of the Basin Mining Co. were operated during a short season and yielded some gold.

South Boulder district.—The ore produced from 7 deep mines aggregated 260 tons and contained $2,060 in gold, 2,964 ounces of silver, 19,510 pounds of copper, and 872 pounds of lead, valued in all at $7,018, or an average value per ton of $26.99. The output in 1914 was 342 tons with an average value per ton of $29.35. A little more than half of the ore was of shipping grade and contained the copper and lead, and the remainder, 122 tons, produced gold and silver bullion. The principal production, chiefly of bullion, came from the Gold Reef property, operated by lessees. A small shipment of oxidized copper ore was made from the North Star mine, and the Brooklyn mine yielded a few tons of silver ore containing copper. The placers in Princeton Gulch yielded a quantity of bullion, most of which had a fineness of about 817.

JEFFERSON COUNTY.

Mine production in Jefferson County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	60	15,997	$79,036	125,858	65,633	461,944	1,923,286	$273,468
1915	74	11,229	73,952	93,441	70,627	975,852	19,796	182,007
Increase or decrease, 1915		−4,768	−5,084	−32,417	+4,994	+513,908	−1,903,490	−91,461

[a] Includes placer production.

Sixty-five deep-mine producers in 1915 reported 4,768 tons of ore less than was reported by 49 producers in 1914. The total average value per ton decreased from $16.90 in 1914 to $16.10 in 1915, and gold and silver value per ton in this ore increased from $9.10 to $10.69. Most of the ore produced, or 10,633 tons, was of shipping grade, and contained $72,099 in gold, 90,858 ounces of silver, 47,095 pounds of copper, and 952,961 pounds of lead, valued in all at $171,195, or an average value per ton of $16.10. A large quantity of old tailings was re-treated and produced zinc concentrate. These tailings are not included in the county production in 1915, as was erroneously done in 1914, but are credited to the source from which they originated—the Butte district in Silver Bow County. However, there were 591 tons of ore concentrated in Jefferson County, which yielded 220 tons of concentrates containing gold, silver, copper, lead, and zinc, valued in all at $9,476, or an average value per ton of $43.07. The greater part of the ore output (5,538 tons) was

classified as dry or siliceous ore, and 4,600 tons were classified as lead ore. The remainder of the output consisted of 930 tons of copper ore, 120 tons of lead-zinc ore, and 41 tons of copper-lead ore. The production of 9 placer operators amounted to $1,267 in gold and 13 ounces of silver, against a production of $3,095 in gold and 29 ounces of silver in 1914.

Amazon district.—A small output of lead ore and a few tons of gold ore, reported to have been produced from three properties, were shipped from the district in 1915.

Boulder district.—The Baltimore property, operated by lessees, yielded a few tons of low-grade silver ore carrying copper and gold. Some placer bullion was recovered from sluicing operations in testing the Wood's placer in Wilson Gulch.

Cataract (including Lowland) district.—Eighteen producers of ore reported an output aggregating 1,190 tons, containing $7,485 in gold, 24,801 ounces of silver, 14,959 pounds of copper, 156,849 pounds of lead, and 19,796 pounds of zinc, valued in all at $32,504, or an average value per ton of $27.31. The principal mine was the Minneapolis, which produced lead ore of shipping grade and some concentrates. Lead ore carrying silver and gold was also shipped from the Bullion and Gray Eagle properties. Other producers were the Corbett, Crystal, East and West Rumley, and Solar Pearl. In Overland Gulch the Erin placer produced a small amount of gold.

Colorado district.—Eleven deep mines produced 4,204 tons of ore containing $10,019 in gold, 53,154 ounces of silver, 26,196 pounds of copper, and 718,845 pounds of lead, valued in all at $75,338, or an average value per ton of $17.97. The greater part of this output was shipped. There were 360 tons of ore milled producing concentrates which contained principally copper, with a little silver and gold. The largest quanity of ore was shipped from the Mount Washington property, which is developed by an incline shaft 530 feet deep and has a tunnel 2,500 feet long. The ore is oxidized with a basic gangue of zinc, iron, and arsenic. The oxidized ores extend to about 400 feet below the surface. The other producers were the Atlas, Hattie, Blue Bird, and Copper Butte claims.

Elkhorn district.—Sixteen deep mines reported production of 4,675 tons of ore, containing $32,483 in gold, 6,315 ounces of silver, 27,533 pounds of copper, 31,778 pounds of lead, valued in all at $41,997, or an average value per ton of $8.98. The ore, with the exception of 111 tons which were concentrated, was of smelting grade. The Golden Curry was the largest producer of oxidized gold ore, carrying a little copper and silver. The iron content ranged from 42 to 55 per cent, and the silica from 7 to 22 per cent. Considerable siliceous gold ore and some oxidized copper ore was shipped from the Moreau property, operated by the Pittsmont smelter interests. This property has a vertical shaft 100 feet deep. Smaller quantities of ore were produced from the Albion, Black Diamond, Center Reef, Elkhorn Queen, Sophia, Bismark, Lucky Strike, Mount Pleasant, Peacock and Turkey, and Passover mines.

Homestake district.—A small quantity of ore from the Hackensack claim was treated in an arrastre and yielded gold bullion. Some ore of shipping grade was produced from three other properties in the district.

Lump Gulch district.—Four deep mines yielded 119 tons of ore, containing gold, silver, lead, and a little copper, having an average value per ton of $42.18. The principal producers were the Liverpool, Little Jim, and Badger properties. Some placer gold was produced from the Botkin workings.

McClellan Creek district.—The Ophir placer produced a small quantity of gold.

Mitchell Gulch district.—Mixed sulphide and oxidized ores, carrying principally gold with some silver and a little copper, were shipped from the John claim. There is a two-stamp mill on the property, which is opened by a vertical shaft 90 feet deep and 350 feet of drifts. Some gold ore was shipped from the Last Hope claim. Placers in the Palo Alto section yielded some bullion.

Whitehall district.—Four deep mine producers reported 178 tons of ore, containing $5,711 in gold, 280 ounces of silver, and 4,588 pounds of lead, valued in all at $6,069, or an average value per ton of $34.10. All the ore was shipped. The Sunlight property was the principal producer of gold ore. The same kind of ore was shipped from the Avon and Argus properties.

LEWIS AND CLARK COUNTY.

Mine production in Lewis and Clark County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Placers:								
1914	31	.....	$8,310	80	.....	.....	.....	$8,354
1915	34	.....	9,422	133	.....	.....	.....	9,489
Deep mines:								
1914	42	25,348	112,121	59,776	16,167	804,511	.....	178,703
1915	82	64,311	533,160	159,412	16,907	1,562,330	13,600	692,056
Increase, 1915	.....	38,963	422,151	99,689	740	757,819	13,600	514,488

The output of ore reported by 82 producers was 38,963 tons greater than was produced by 42 operators in 1914. The total average value per ton increased from $7.05 in 1914 to $10.76 in 1915 and the gold and silver value per ton from $5.73 to $9.55. The greater part of the ore was of milling grade, which was treated principally by cyanidation and yielded gold and silver bullion containing $219,264 in gold and 25,768 ounces of silver, having an average value of $4.77 per ton. Crude ores shipped aggregated 11,510 tons, and contained $312,466 in gold, 132,810 ounces of silver, 16,907 pounds of copper, 1,562,330 pounds of lead, and 13,600 pounds of zinc, valued in all at $457,875, or an average value per ton of $39.78. Most of the ore mined (60,122 tons) was dry or siliceous in character. There were also produced 4,086 tons of lead ore, 75 tons of copper ore, and 28 tons of zinc ore. The placer output of 34 producers amounted to $9,422 in gold and 133 ounces of silver, against $8,310 in gold and 80 ounces of silver in 1914.

Bald Butte district.—A large quantity of tailing from the Bald Butte dump was treated, yielding gold and silver by cyanidation. The plant was operated in an experimental way during the latter part of the year. The Eureka property yielded gold ore, which was

also treated by cyanidation. This property is opened by a vertical shaft 100 feet deep.

Big Blackfoot district.—The Lockey claim produced a small tonnage of gold ore of shipping grade, and some milling ore was treated in an arrastre and yielded gold bullion.

Dry Gulch district.—The ore mined by 6 producers aggregated 8,605 tons. The greater part of the output was that of the Golden Messenger property, which is opened by shallow shafts and has a 50-ton cyanide plant, in which the ore is finely ground, agitated, and passed to percolating tanks. The cyanide precipitates are reduced at the property, and the resulting bullion is shipped. The remainder of the district output, $3,922 in gold and 85 ounces of silver, was produced from 8 placers. The placers producing were those in Oregon, Kingsbury, and New York gulches.

Gladstone district.—The property of the Helena Gold & Iron Co., which is opened by a 212-foot adit, was under development during the year, and a small quantity of copper ore was shipped.

Gould district.—Some gold and silver bullion was reported from the amalgamation and cyanidation tests on ore from one property in the district.

Greenhorn district.—The Umatilla and May properties were operated during the early part of the year. The ore was treated by amalgamation in a 5-stamp mill and some gold and silver bullion was recovered. A few tons of gold and silver ore of shipping grade were produced. The placers in Greenhorn and Nelson Gulches produced some gold.

Helena district.—Ore produced from 18 properties aggregated 353 tons and contained $4,383 in gold, 2,405 ounces of silver, 2,428 pounds of copper, 17,342 pounds of lead, and 13,600 pounds of zinc, valued in all at $8,528, or an average value per ton of $24.16. The greater part of the ore, 227 tons, was of shipping grade, containing copper, lead, and zinc, and 126 tons of ore produced gold and silver bullion. The Yellow Boy claim produced some gold and silver ore, which was treated in an amalgamation mill. The Pearl and Arrowhead properties produced gold ore of shipping grade. The placer output amounted to $848 in gold and 5 ounces of silver, reported from 7 sources.

Jefferson Gulch district.—Some gold and silver bullion and some concentrate recovered from ore was reported by one producer in the district.

Lincoln district.—A few tons of lead-copper ore were reported from the Mike Horse property, which is being worked by the O. & M. Mines Co. The placer output reported from 2 properties was small.

Little Creek district.—A small quantity of copper sulphide ore was shipped from the King Bee and Bear properties near Wolf Creek post office.

Ottawa district.—There were 26,365 tons of ore, including 1,715 tons of old tailings, sold or treated in 1915. The larger part (24,391 tons) was milled and yielded gold and silver bullion and a small quantity of concentrate containing gold and silver, and 261 tons containing gold, silver, copper, and lead were shipped directly to the smelters. The total ore output of the district was valued at $166,954, or an average value per ton of $6.33. Considerable ore was mined

and milled from the Piegan-Gloster property, on which a 150-ton concentration, cyanidation, and amalgamation mill was operated. This mill was completed in May, 1915. The ore, principally a sulphide, is crushed and ground in solution in Chile mills, concentrated, amalgamated, the sands leached, and the slimes agitated and then filter pressed. During the first five months of 1915 the installation of mill machinery at the Piegan-Gloster[1] was completed and other renewals and repair work in the mine were hastened. The Piegan-Gloster group includes 34 claims and covers 391 acres. The company's annual report contains the following:

> Stoping in the Piegan ground and at the west end of the Gloster ore shoot produced more waste rock from soft walls than anticipated, and the latter stope narrowed quickly, so that the average assay of all ore mined for the period was but $7.34, of which $1.14 was silver value.
>
> A total of 14,956 tons of ore were mined and milled during the seven months, and 5,110 tons of broken ore were still in the stopes at the close of the year.
>
> Of the gold and silver values, 85.2 per cent were saved by combined cyanide, amalgamation, and concentration treatment, and the gross value of the bullion and concentrates sold was $86,171.37.
>
> Of the values recovered, 78.2 per cent was by cyanide, 19.9 per cent by amalgamation, and 1.9 per cent by concentration. * * *
>
> The Shannon mine, a group of 6 claims (92 acres), but 1 of which is patented, situated 2½ miles southwest of Marysville and close to the summit of the Continental Divide, was taken under option June 1. * * *
>
> For the treatment of Shannon ore, it is planned to convert the Gloster mill to an all-slime treatment plant, utilizing all the present machinery and tanks, with the necessary additions to give a capacity of 150 tons per day.

There was also a large quantity of ore treated at the Cruse and Bald Mountain mill, in which the ore is treated by cyanidation and amalgamation. Gold and silver ore was shipped from the Drumlummon and Morning Star properties, and about 800 tons of old Penobscot tailings were re-treated by cyanidation. Miscellaneous tailings were treated in Canyon Creek by cyanidation and yielded some gold and silver bullion.

Poorman district.—A small quantity of gold and silver ore and some placer bullion was produced from two deep mines and three placers in 1915. The total output was valued at $1,904.

Scratch Gravel district.—The Franklin mine and the Scratch Gravel Gold property were the principal producers, and shipped gold ore carrying some silver, all of shipping grade. Less important shipments were made from the Eastern Bell and Morning Star properties.

Seven Mile district.—Some oxidized lead ore was shipped by lessees from one property in the district.

Stemple district.—The output reported by six deep-mine producers aggregated 60 tons of ore, containing gold and silver valued at $1,492, or an average value per ton of $24.87. Thirty-six tons of the ore was milled and yielded gold and silver bullion, and the remainder, 24 tons, was shipped directly to the smelters. The producers were the Blackwater, Last Chance, Hard Rock, and Klondyke. The last-named property has an amalgamation mill, and some gold and silver bullion was produced. The placer output reported from three sources amounted to $227 in gold and 2 ounces of silver.

Springhill district.—The total output of the district, which included the ore shipped by three producers and bullion from two

[1] Barnes King Development Co. Ann. Rept. for year ending Dec. 31, 1915.

placers, amounted to $833. The ore, which contained principally gold and silver, with a little copper, from two properties, had an average value per ton of $18.70. Some sluicing was carried on in Skelly Gulch.

Three Mile district.—One property in the district was developed and a small quantity of copper ore mined and shipped.

Unionville district.—Two producers mined 713 tons, all of which, except 2 tons, was milled and yielded gold and silver bullion and a small quantity of concentrate, which was stored. The average value per ton of the ore mined in the district was $12.06. Some gold and silver bullion was reported from placers operated in Grizzly Gulch.

Vaughn district.—There was an increase in the production of ore and in the number of operators in 1915. Ten deep mines reported the output of 18,474 tons of ore, of which 14,443 tons were milled, yielding gold and silver bullion by amalgamation, and 4,029 tons containing gold, silver, and lead, with a little copper, were shipped to smelters. The total ore output of the district had an average value per ton of $8.19. The greatest part of the production came from the "Porphyry Dyke Gold" property, which is opened by an adit 1,000 feet in length. The ore is treated in an amalgamation mill. Lead sulphide ore of shipping grade was mined from the Valley Forge property. Other producers were the Stanton, Mary Alois, San Juan, Mabel, May Rilly, and Montana properties. The principal placers producing were the Perseverance and the Tucker Gulch.

LINCOLN COUNTY.

Two deep-mine operators reported 377 tons of ore containing gold, silver, and lead, valued in all at $9,250, or an average value per ton of $24.54. The output of the placers reported by six producers amounted to $2,527 in gold and 11 ounces of silver. The placer production in 1914 amounted to only $37, and no ore was reported having been produced in the county.

Libby district.—The output of two deep mines and five placers aggregated $6,454 in gold, 4,058 ounces of silver, and 53,305 pounds of lead, valued in all at $11,016. The ore shipped aggregated 377 tons and averaged $24.54 per ton. The principal placers operated were the Bear Creek, Howard Lake, and Montana. The largest operations were reported by the Bear Creek property, where a steam shovel discharging into sluices was operated.

Sylvanite district.—The Solo Joe placer, operated under lease, produced some bullion.

MADISON COUNTY.

Mine production in Madison County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
Placers:							
1914	13	.....	$836,097	6,149	.....	.....	$839,497
1915	11	.....	862,719	7,240	.....	.....	866,390
Deep mines:							
1914	90	27,212	281,853	174,222	36,218	150,265	388,875
1915	115	19,147	274,293	91,446	18,051	283,453	337,137
Increase or decrease, 1915	.....	−8,065	+19,062	−81,685	−18,167	+133,188	−24,815

In 1915 there were 115 deep-mine operators reporting 8,065 tons of ore less than was produced by 90 operators in 1914. The total average value per ton increased from $14.29 in 1914 to $17.61 in 1915 and the gold and silver value per ton from $13.90 to $16.75. Most of the ore (15,399 tons) was treated at gold and silver mills and yielded bullion containing $63,227 in gold and 38,701 ounces of silver, with an average value per ton of $5.38. In addition to the bullion there were some concentrates containing gold and silver produced. Only 403 tons of ore were directly concentrated, and this ore contained a small quantity of copper. There were 3,345 tons of ore shipped, containing $142,665 in gold, 31,503 ounces of silver, 14,191 pounds of copper, 283,453 pounds of lead, valued in all at $174,442, or an average value per ton of $52.15. Of the ore mined 18,443 tons were classified as dry or siliceous ore, 693 tons as lead ore, and 11 tons as copper ore. Placer bullion reported by 11 producers amounted to $862,719 in gold and 7,240 ounces of silver, against a placer output by 13 producers of $836,097 in gold and 6,149 ounces of silver in 1914.

Alder Gulch district.—There were 136 tons of ore of smelting grade produced and 93 tons were treated in a gold and silver mill, yielding bullion. The ore shipped to the smelters was the output of 17 producers and contained gold, silver, lead, and a little copper. The total value of the ore was $7,942, or an average value per ton of $34.68. The principal output of the district came from the placers, of which five reported the output of $860,686 in gold and 7,234 ounces of silver. Dredging of the Conrey placer ground at Ruby continued to be the principal source of gold bullion. Altogether the four dredges, which are electrically operated, handled about 6,000,000 cubic yards of gravel in 1915.

Lower Hot Springs district.—Six deep mines produced 55 tons of ore containing gold and silver, with a little lead and copper, valued in all at $3,407, or an average value per ton of $61.95. The principal properties producing were the Greaser group and the Gold Reef.

Mineral Hill district.—The output reported by 6 producers was 10,101 tons of ore containing $83,523 in gold, 2,923 ounces of silver, and 3,195 pounds of copper, valued in all at $85,564, or an average value per ton of $8.47. The greater part of this ore was milled and yielded gold and silver bullion and concentrate. There were only 55 tons of ore containing principally gold shipped directly to smelters. The largest producer was the Boss Tweed & Clipper group. Smaller productions came from the Oregon, Garnet, and Union properties.

Norwegian district.—All the ore shipped (181 tons) was produced by 6 operators and contained $7,383 in gold, 925 ounces of silver, and 2,070 pounds of copper, valued in all at $8,214, or an average value per ton of $45.38. The principal producers were the Bonanza Fraction, Colorado, Last Chance, Mary Ingabar, Gold Hill, and O. K. claims.

Rabbit district.—Five deep mines produced 283 tons of ore of shipping grade, containing gold, silver, lead, and a little copper, valued in all at $11,551, or an average value per ton of $40.82. The ore produced was mostly oxidized lead ore, and was mined from the Champion, Polly Jane, and Emma properties, which were the principal properties operated.

Ramshorn district.—The output of 4 deep mines, aggregating 29 tons of ore of shipping grade, contained gold and silver. The ore produced was principally from the Betsy Baker property. Placer bullion reported by 4 producers amounted to $1,844 in gold and 6 ounces of silver.

Sheridan district.—The principal part of the ore, or 650 tons, made by 16 producers was milled and 332 tons, carrying gold, silver, copper, and lead, was shipped directly to the smelters. The total value of the output amounted to $28,445, or an average value per ton of $28.97. The Lake Shore & Gladstone and Tamarack & Paymaster mines were the principal producers.

Silver Star district.—There were 863 tons of ore produced in the district reported by 13 operators. The larger part (479 tons), carrying gold, silver, copper, and lead, was shipped directly to the smelters, 363 tons were concentrated, yielding gold and silver, and 21 tons were treated at a gold and silver mill, yielding bullion. The Broadway, Greene-Campbell, and Hudson were the principal producers.

Summit district.—Nine producers reported the production of 4,218 tons of ore, the most of which, or 3,978 tons, was treated at milling plants and yielded gold and silver bullion and some concentrate. There were 240 tons of ore containing gold and silver shipped directly to the smelters. The total value of the entire output was $68,538, or an average value per ton of $16.25. The largest producer was the Easton Pacific, which shipped silver bullion containing a little gold and a concentrate containing gold and silver. The Homestake and Black Rock properties were also producers of gold and silver ore of shipping grade. At the Winnetka property a little gold and silver ore was taken out in doing development work.

Tidal Wave district.—Twenty-three producers reported 1,100 tons of ore. The larger part, or 631 tons, containing gold, silver, and lead, was shipped directly to the smelter, and 469 tons yielded gold and silver bullion at two milling plants. The principal shippers of ore were the Eleanor and Moonlight properties. Considerable milling ore was treated at the mill on the Florida Giant property.

Upper Hot Springs district.—The output reported by six producers aggregated 108 tons of ore, all of shipping grade, containing principally gold and silver and a little copper, valued at $6,389, or an average value per ton of $59.15. The principal producers were the Bull Moose, Lexington, and Monitor and Revenue properties.

Washington district.—Four producers reported the production of 998 tons of ore. The greater part (816 tons) was of shipping grade and contained gold, silver, and a little copper. The remainder 182 tons, was treated at milling plants and produced gold and silver bullion. Most of the ore was mined from the Missouri property, and ore and bullion was produced from the Lehigh property.

MEAGHER COUNTY.

There were 13 tons of ore produced in 1915 containing copper and silver, with an average value per ton of $46.23, against an output of 26 tons in 1914, having an average value per ton of $37.81. The ore shipped in 1914 contained zinc and copper. The output of two placers was $225 in gold and 2 ounces of silver, against a production

of $186 in gold and 2 ounces of silver reported by the same number of producers in 1914.

Diamond district.—Prospectors working in the district reported the output of some placer gold.

Musselshell district.—The Lucky Boy property was the producer of a small quantity of copper ore in 1915.

MINERAL COUNTY.

The greater portion of the mineral area, formerly in Missoula County, which became Mineral County on August 7, 1914, had 6 producers in 1915 reporting 50,491 tons of ore, containing $773 in gold, 123,221 ounces of silver, 36,502 pounds of copper, 1,528,661 pounds of lead, and 432,283 pounds of zinc, valued in all at $195,084, or an average value per ton of $3.86. This output consisted largely of lead-zinc ore (49,998 tons), which was concentrated and yielded a concentrate which contained lead and zinc, with gold, silver, and copper values, and which averaged per ton $73.49. The ore shipped aggregated 330 tons, and contained $762 in gold, 8,889 ounces of silver, 20,223 pounds of copper, 100,776 pounds of lead, and 26,775 pounds of zinc, valued in all at $16,864, or an average value per ton of $51.10. The placer bullion reported by 13 producers amounted to $12,389 in gold and 24 ounces of silver.

Cedar Creek district.—The largest part of the metal output was from placers, 13 of which reported $12,389 in gold and 24 ounces of silver. The only deep mine operations were on the Amador property and produced copper ore, which was milled in a concentrating plant and the product was shipped to Butte for treatment. The Windfall, Cedar Creek, Stockholm, and C. B. & Q. placers were operated during part of 1915.

Iron Mountain district.—The Iron Mountain Tunnel property was purchased by the Federal Mining & Smelting Co. in July, 1915. The property produced the entire year a lead-zinc ore, which was milled and the lead concentrates disposed of at Helena and the zinc product shipped to a plant in Colorado.

St. Regis district.—The St. Lawrence property produced a quantity of copper oxidized ore, carrying good values in gold.

Saltese district.—In doing assessment work, the company operating the Bald Mountain Copper property shipped some copper ore carrying small values in gold and silver.

MISSOULA COUNTY.

Six deep mines produced 2,444 tons of ore. The principal part, or 1,235 tons, yielded gold and silver bullion, and 84 tons were shipped directly to the smelters. The total output contained $10,912 in gold, 233 ounces of silver, 3,120 pounds of copper, valued in all at $11,577, or an average value per ton of $4.74. There were 12 placer producers yielding gold and silver bullion amounting to $4,321 in gold and 9 ounces of silver.

Bear Gulch district.—On the divide between Elk Creek and Deep Gulch a small quantity of placer gold was mined from the Alabama property.

Coloma district.—The Dandy group was the only deep mine producer and had an output of siliceous gold ore carrying a little copper and silver, which was shipped directly to the smelter. There is a 40-ton amalgamation and concentration plant on the property, but it was not completed in time to make a clean-up of the bullion produced in 1915. Some placer gold was produced from the Elk Creek properties and sold to the storekeepers in the district.

Nine Mile district.—Two deep mines reported the production of 2,360 tons of ore and old tailings, all of which yielded gold and silver bullion in amalgamation plants. Nine placers reported the output of $3,637 in gold and 5 ounces of silver. The deep mines operating were the Nine Mile and Martina, and the principal placers were the Chrysalis, Pine Creek, and Slide.

Ravalli district.—The McDonald property yielded a few tons of copper ore containing a little silver.

PARK COUNTY.

Some development work was done in 1915, but there was no production of ore reported. Five producers of placer bullion reported an output of $2,367 in gold and 19 ounces of silver in 1915, against $888 in gold and 4 ounces of silver in 1914.

Crevasse district.—A small quantity of placer gold was reported by bullion buyers as having been produced in the district in 1915.

Emigrant Creek district.—An output of $2,259 in gold and 17 ounces of silver was reported from the various placer properties in the district. The Bob Tail and Pittsburg were the principal producers.

PHILLIPS COUNTY.

This county was organized during the year from the eastern part of what was formerly Blaine County, which had been formed from part of Chouteau County. The output reported in 1915 by three deep mine producers was 227,922 tons of ore and 10,000 tons of old tailings, which were treated by cyanidation, and produced bullion valued at $558,184. The ore treated was 116,763 tons more than was treated in 1914.

Little Rockies district.—Three mining properties produced gold and silver from the treatment of ore and old tailings by cyanidation. The largest producer was the Ruby Gulch property, and some output was also reported from the August and Beaver Creek properties.

POWELL COUNTY.

Mine production in Powell County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
Placers:							
1914	23	.....	$25,302	183	.....	.....	$25,403
1915	20	.....	18,692	111	.....	.....	18,748
Deep mines:							
1914	13	1,854	20,080	64,257	78,386	81,717	69,226
1915	32	1,093	22,109	18,728	9,160	139,188	39,749
Increase or decrease, 1915	.....	−761	−1,581	−45,601	−69,226	+57,471	−36,132

Thirty-two operators reported in 1915 the production or shipment of 1,093 tons of ore, which is 761 tons greater than was produced by 13 operators in 1914. The total value per ton decreased from $37.34 in 1914 to $36.37 in 1915, and the gold and silver value per ton decreased from $30 to $28.91. The bulk of the ore, or 1,035 tons, was of shipping grade, containing $20,980 in gold, 18,713 ounces of silver, 9,160 pounds of copper, and 139,188 pounds of lead, valued in all at $38,612, or an average value per ton of $37.30. Twenty placer producers reported $18,692 in gold and 111 ounces of silver in 1915, against an output of $25,302 in gold and 183 ounces of silver in 1914.

Big Blackfoot district.—A small quantity of iron sulphide ore, carrying gold and silver, was shipped from Moose Creek. The Bonanza was the principal producer.

Ontario district.—The output reported from 17 deep mines and 2 placer properties contained $15,563 in gold, 7,385 ounces of silver, 6,667 pounds of copper, and 96,147 pounds of lead, valued in all at $24,993. The ore produced was all shipped and averaged $37.57 per ton. Lead ore carrying silver and gold was shipped from the Democrat, Big Dick, Black Jack, Carbonate Extension, and Argus properties. Some ore carrying lead and gold was shipped from the Carbonate King property.

Ophir district.—Four deep-mine producers reported the output of 52 tons of shipping ore containing gold, silver, copper, and lead, averaging $20.81 per ton. The output reported from 11 placers amounted to $2,596 in gold and 11 ounces of silver, as against an output reported in 1914 of $1,058 in gold and 5 ounces of silver.

Pioneer district.—Two operators produced 58 tons of ore containing gold and silver, and $13,449 in gold and 84 ounces of silver were reported from 6 placers. The most productive of the placers were the Pioneer, Upper Gold Creek, and Friday properties.

Washington Gulch district.—The Scotch Bar and Herman Ruther placers operated by hydraulic and drift mining produced some gold and silver bullion.

Zozell district.—Six deep mines shipped 324 tons of ore containing $5,900 in gold, 10,380 ounces of silver, 41,645 pounds of lead, and a little copper, valued in all at $13,221, or an average value per ton of $40.81. The Black Eyed Maggie and Emery properties were the most productive.

RAVALLI COUNTY.

One operator reported the treatment of some old tailings from which a zinc concentrate containing gold and silver and a little lead was recovered. The placer output reported by 4 producers amounted to $19,190 in gold and 63 ounces of silver, as against an output made by 3 operators in 1914, amounting to $6,260 in gold and 20 ounces of silver.

Curlew district.—The Victor Reduction Co. operated during the latter part of 1915 on old tailings and shipped some concentrates containing principally zinc, a little lead, and some gold and silver. The property is equipped with a 100-ton concentration mill, in which the tailings are reground, passed over tables, and flotation is applied to the slimes.

Hughes Creek district.—Gold bullion was produced principally from the Wood placer, which operated about 160 days in 1915.

SANDERS COUNTY.

Three deep-mine producers reported the output of 245 tons of ore, which was shipped and produced $263 in gold, 3,273 ounces of silver, 37,607 pounds of copper, and 34,311 pounds of lead, valued in all at $10,117, or an average value per ton of $41.29. Compared with 1914, the output was 123 tons greater, but the total average value per ton decreased from $55.33 in 1914 to $41.29 in 1915 and the gold and silver value per ton from $16.64 to $7.85. Of the output, 174 tons was classified as copper-lead ore. The remainder was copper ore.

Perma district.—Some copper ore, carrying a little silver, was shipped from the Exchange property.

Revais Creek district.—Copper ore, carrying values in gold and silver, was shipped from the Dixon property.

Spring Gulch district.—The King and Queen property produced shipping ore containing copper and lead, with some silver and gold.

Trout Creek district.—Placers on Clark Fork River and near Trout Creek post office were operated and produced a small quantity of placer bullion.

SILVER BOW COUNTY.

Mine production in Silver Bow County, Mont., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	67	4,749,189	$657,176	10,511,032	232,188,628	5,386,356	109,542,542	$43,147,603
1915	63	5,574,105	809,314	12,484,609	266,006,469	7,936,121	186,514,375	77,190,924
Increase, 1915		824,916	152,138	1,973,577	33,817,841	2,549,765	76,971,833	34,043,321

[a] Includes placer production.

Practically all of the ore produced in the county is from Butte or Summit Valley district. Fifty-eight deep-mine producers in the county reported 5,574,105 tons of ore. This was 824,916 tons more than was reported in 1914 by 61 operators. Most of this ore was produced by a few large operators. The remainder of the producers were lessees operating on various properties. The total average value per ton increased from $9.08 in 1914 to $13.85 in 1915, but the gold and silver value per ton in this ore decreased from $1.36 to $1.28. The gold produced from both deep mines and placers increased in value from $657,176 in 1914 to $809,314 in 1915, the silver from $5,812,601 to $6,329,697, and the copper from $30,881,088 to $46,551,132. The expansion in the mining of lead-zinc ore also increased the value of lead from $210,068 in 1914 to $372,998 in 1915, and that of zinc from $5,586,670 to $23,127,783. The total value of all metals increased from $43,147,603 in 1914 to $77,190,924 in 1915. The larger part of the ore produced, 4,935,774 tons, was concentrated at milling plants situated at Butte, Anaconda, and Great Falls. The product consisted of lead concentrates, zinc concentrates, and copper concentrates, aggregating 1,685,354 tons and containing $616,118 in gold, 9,849,318 ounces of silver, 191,957,098 pounds of

copper, 7,931,823 pounds of lead, and 186,299,594 pounds of zinc, valued in all at $62,676,160, or an average value per ton of $37.19. The crude smelting ore amounted to 586,806 tons and contained $188,137 in gold, 2,601,766 ounces of silver, 67,264,248 pounds of copper, 4,298 pounds of lead, and 214,781 pounds of zinc, valued in all at $13,305,311, or an average value per ton of $22.67. A small quantity of gold and silver bullion was produced from 65 tons of one treated at a gold and silver mill. The ores mined were classified as 4,860,110 tons of copper ore, 522,300 tons of lead-zinc ore, 178,545 tons of zinc ore, 13,124 tons of dry or siliceous ore, and 26 tons of lead ore. The placer output was $1,589 in gold and 15 ounces of silver, as against $3,589 in gold and 51 ounces of silver in 1914.

Divide Creek district.—Eleven producers in this region reported the production of 128 tons of ore, all of which, including some gold and silver concentrate recovered from 20 tons of ore, was shipped directly to the smelter and produced $404 in gold, 5,243 ounces of silver, 6,637 pounds of copper, and 4,298 pounds of lead, valued in all at $4,425, or an average value per ton of $34.57. The placer output reported by 1 producer was very small. The Reliance mine, on Moose Creek, and the Oneida mine, on Camp Creek, were producers; their production is included in the total.

Highland district.—Placer properties were worked in the district and so far as known the production amounted to $1,570 in gold and 15 ounces of silver.

Butte or Summit Valley district.—The great bulk of metallic wealth credited to Silver Bow County is the output of this district. Its total value, beginning with the year 1882 to the end of 1915, amounted to $1,216,767,731, divided as follows: Gold, $27,732,923; silver, $203,904,942; copper, $943,225,330; lead, $1,096,408. The production of zinc began in 1905 and at the end of 1915 the value amounted to $40,808,038. The quantities of the metals for which the values are given above are gold, 1,341,580.15 ounces; silver, 298,109,221 ounces; copper, 6,652,385,069 pounds; lead, 24,617,302 pounds; and zinc, 506,054,129 pounds. Detailed figures by years are given in Mineral Resources for the year 1913.

The Anaconda Copper Co. was the largest producer of copper and of ore mined, followed by the North Butte, East Butte, Balaklava, Pilot Butte, Davis Daly, Tuolumne, Butte Duluth, Alex Scott, Bullwhacker, Poser, and Moulton. The Butte & Superior and the Elm Orlu mines exceeded all former production of zinc. Milling of the ores and the subsequent treatment of their products have met with such success that in 1915 it was stated that the Anaconda concentrating works, by the addition of the oil flotation process, were saving 97.75 per cent of the values in a 3 per cent copper ore. Other items of saving were due to the improvement of the reverberatory smelting process by the introduction of coal-dust firing and to the abandonment of briquetting and blast-furnace smelting in favor of the new reverberatory process. Another saving in costs was made by shipping all the concentrating ore to Anaconda instead of sending some of it to Great Falls. At the end of 1915 this great company announced the success of its new experimental electrolytic zinc plant, from which it produced several hundred thousand pounds of spelter in 1915. The starting of the 2,000-ton copper leaching plant for old

tailings was another event of the year. This is discussed in a recent bulletin,[1] extracts of which are as follows:

After a series of experiments covering a period of about three years, extending from the spring of 1912 to the spring of 1915, a 2,000-ton leaching plant for the treatment of the accumulated copper concentrator tailing was built and put into operation. During the experimental period the first step was that of laboratory experiments or beaker leaches. The results on this small scale were so satisfactory that a small operating plant capable of handling 5 tons of roasted tailing per day was installed. Again, the results proved satisfactory, and an 80-ton plant was built and operated continuously from August until February, 1913. In this plant, full-sized roasting and leaching units were used. The results obtained by the operation of the 80-ton plant proved that the roasting and leaching of deslimed concentrator tailing could be profitably done, so in the early spring of 1914 the construction of a 2,000-ton leaching plant was begun. Operation of the plant began on May 13, 1915. * * *

The accumulated tailing in the New Works dump is estimated at about 20,000,000 tons. The dump consists of the concentrator tailing discharge over a period extending from February, 1902, to the present date. According to daily samples taken during that period, the copper content is about 0.64 per cent and the silver 0.48 ounces per ton. The peak of the dump, or the point where the tailing is discharged, carries about 0.75 per cent copper, while down toward the toe, and where present excavation is taking place, the copper content is only 0.57 per cent. About 3 pounds per ton of the copper is oxidized, the remainder being sulphide. * * *

The practice (of precipitating) here is too old to necessitate much explanation. The main advantages in the practice at this plant over the usual practice are the large launders, which make it possible to put in large and odd-shaped pieces of iron, and the presence of salt in the solutions which prevents the copper from plating on the iron, and makes a soft, spongy cement copper which is easily washed off with a hose, leaving the iron clean for more precipitation. It is never necessary to remove the iron for cleaning. The silver is recovered by precipitation on the precipitated copper.

The resulting cement copper carries about 70 per cent copper. The following data are taken from the reports for the month of October, 1915. This is a representative month, but it is certain that the results will be improved upon after longer operation.

Sand tailing treated	tons	70,401
Copper in feed	per cent	0.575
Silver in feed	ounce per ton	.45
Copper in tailing	per cent	.082
Silver in tailing	ounce per ton	.14
Sulphuric acid (60° Baumé)	pounds per ton of feed	64.90
Coal	per cent of feed	3.30
Salt	do	1.52
Iron	pounds per pound of copper	2.00

The plant during this month made an extraction of about 80 per cent of the copper and 60 per cent of the silver. This is less than indicated by assays of heads and tailings owing to various plant losses, of which the largest is dust from the roasting furnaces amounting to about 4.5 per cent of the copper in the feed.

Analyses of feed and tailing.

	Cu.	Ag.	SiO_2.	FeO.	S.	Al_2O_3.	CaO.
	Per cent.	*Ounces.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*	*Per cent.*
Feed	0.575	0.45	81.3	3.0	2.1	9.4	0.4
Tailing	.082	.14	84.7	2.4	.4	8.7	.4

In 1915 the Anaconda Copper properties[2] produced 4,376,556.53 tons of ore and 6,783.20 tons of precipitates, or a total of 4,383,339.73

[1] Laist, Frederick, and Aldrich, H. W., The 2,000-ton leaching plant at Anaconda; Am. Inst. Min. Eng. Bull. 116, pp. 1281–1293, August, 1916.

[2] Anaconda Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1915.

tons, against a total in 1914 of 3,904,882.58 tons. The reduction works treated for all companies 4,421,628.69 tons of ore and other cupriferous material at Anaconda and 384,065.56 tons of ore and other cupriferous material at Great Falls. Of this quantity, 4,258,129.03 tons of ore were produced by company mines, 535,223.16 tons of ore were either purchased from or treated for other companies, and 12,342.06 tons of precipitates and cleanings were from the old works at Anaconda; and from this quantity there was produced 254,311,574 pounds of fine copper, 9,005,617.68 ounces of silver, and 106,702.75 ounces of gold. Of this total, 235,076,289 pounds of fine copper, 8,064,986.02 ounces of silver, and 106,702.748 ounces of gold were produced from the mines of the company. From the Anaconda Co.'s report the following notes are taken:

The concentrator, consisting of eight sections, each of which formerly treated about 1,500 tons of ore per day, has been completely remodeled. The entire operation was one of water concentration. This method has been changed by introducing oil flotation at a stage of the operation subsequent to the removal from the gangue of the richer and coarser particles of ore. The results which have been accomplished have exceeded expectations and are regarded as setting a new standard for this branch of metallurgy. The capacity of the concentrator has been increased from about 12,000 to 15,000 tons of crude ore per day. The first of the remodeled sections was put in operation in May, and an additional section on the average of every 30 days thereafter has been added until the entire concentrator in remodeled design is treating ore to the full capacity planned. The recovery of copper in concentrates has been increased from 82 per cent of the content of the ore to 96 per cent with a comparatively small increase in the treatment cost per ton. On the basis of 3 per cent ore this increased recovery represents 8.4 pounds of copper per ton of ore treated, with proportionately increased recoveries of the precious metals found in association with the copper.

One of the difficult problems of ore concentration has accomplished the effort to extract the finely divided metalliferous particles from the more or less clayey portion of the gangue, and a considerable loss has been heretofore sustained in the flow of this portion of the pulp, designated as "slimes." A round table plant had been built about four years ago to handle the current slimes and had operated successfully until the demonstrated superiority of the flotation process for handling this material decided the management to dismantle the round table plant and erect a flotation plant possessing sufficient capacity to take care of current output and also to treat the material which for many years had been deposited in huge ponds which had been provided for settling the slimes. Such a flotation plant has been erected, capable of handling 4,000 tons of slimes per day, 3,000 tons of which will come from current operation and 1,000 tons of which are taken from the accumulation stored by the method above referred to. A recovery of 90 per cent is being made from the stored slimes above mentioned. This operation alone adds 900,000 pounds of copper per month to production at a cost of about 5 cents per pound.

The greater tonnage to be treated by the concentrating plant, together with increased recoveries above noted, made necessary additional capacity to roast the concentrates produced. Therefore a new plant containing twenty-eight 25-foot roasters has been built and is practically ready for operation. The Cottrell system of fume treatment has been installed in connection with this plant, and the result will be a decrease in the loss of metals in waste gases.

A large supply of cheap sulphuric acid is an important factor to the economical operation of both the flotation and leaching processes above mentioned. The copper ores treated by the company from its Butte mines are sulphides, and as part of the process of their reduction involves the liberation of large volumes of sulphur gases, it was decided to build a sulphuric-acid plant, of the chamber type, capable of making an output of 100 tons per day of 60° Baumé acid. This plant has been completed and has been operating for several months in a most satisfactory manner. During the last quarter of the year 1915, 9,781 tons of acid were produced at a very low cost. The production of the plant is sufficient to meet the requirements of the company and leave a surplus which finds a ready sale at prices sufficiently high to make the enterprise a profitable

one. The growing demand for this product for our own needs and to supply others in our territory has caused the management to decide to add an extension to the plant, which will increase its capacity to 150 tons per day. This addition is now under construction and will be completed within a few months.

The loss heretofore sustained in concentrating resulted in the reduction of copper ores in blast furnaces whenever the copper content was sufficiently high and the ore of such character as to permit the use of this method, notwithstanding the cheaper cost per ton of material treated by smelting in reverberatory furnaces. The increased saving in concentration makes it a desirable method of preliminary treatment, while the extremely fine character of the concentrates produced by flotation makes the product essentially one for reverbatory smelting. Experimentation at Anaconda and elsewhere had demonstrated that great economy could be obtained from the practice of pulverized-coal firing instead of the method of stoking then in use. It was therefore decided to rebuild the reverberatory furnaces, equip them with suitable apparatus for coal-dust firing, and enlarge them sufficiently to provide for the reduction of the greatly increased tonnage made possible by this method of firing. Eight new furnaces, having hearth dimensions of 143 feet by 23 feet, have been built. Under the former practice the plant treated 250 tons per furnace day at a ratio of 4 tons of charge treated to 1 ton of coal burned. Under the new practice the plant is treating 650 tons per furnace day, with a ratio of 6.8 tons of charge treated to 1 ton of coal burned. In addition to the increased product obtained, a saving of 50 cents per ton of charge treated in operating costs has been made in this department. * * *

Prior to the consolidation of the properties now owned by the Anaconda Copper Mining Co., the Boston & Montana Co. was conducting all of its smelting and refining operations at the plant at Great Falls. The desirability of the company owning and operating two smelting plants, as well as the many natural advantages possessed by the site occupied, including its availability to cheap hydroelectric power generated in its immediate vicinity, impelled the management to decide to remodel and continue operating the smelting department of this plant. It is intended to abandon the concentrating department in the immediate future, as the concentrator at Anaconda will supply sufficient concentrates for both smelters. Advantage can thus be taken of the efficiency of the Anaconda plant, while at the same time a considerable saving in freight charges will be effected by transporting concentrates from Anaconda to Great Falls instead of crude ore from Butte to Great Falls. The plan adopted for this plant involved remodeling of the roasting department, rebuilding the reverberatory furnaces, equipping them with pulverized coal-firing apparatus, and installing in the converter plant the "Great Falls" type of converters. This work has been practically completed, and the plant on its remodeled basis will reduce satisfactorily and economically the concentrates shipped to it.

The anticipated increased output of the smelting plants of the company as well as the requirement for additional capacity at the Raritan refinery in New Jersey to refine the copper consigned to it on toll made it necessary to provide the company with increased refining capacity. The old Boston & Montana refinery at Great Falls, capable of making an output of about 60,000,000 pounds of copper per annum had become obsolete. A careful study of market distribution of the product, freight rates, etc., resulted in the decision to build a modern electrolytic refinery at Great Falls capable of making an output of 180,000,000 pounds of copper per annum. This plant has been practically completed, all important construction having been finished by January 1, 1916. Delay in starting has been occasioned by the failure on the part of manufacturers to deliver necessary incidentals, but the plant will be in operation prior to March 1. It is estimated that a saving of $3 per ton of refined copper will be made on the cost of refining at the old plant.

* * * In many of the mining districts of the West, particularly those which are producers of either silver-lead or copper ores, zinc in varying quantities forms an important and hitherto very objectionable constituent. Found usually in quantities insufficient to justify working the ores for the recovery of this metal, its presence occasioned the metallurgist numerous difficulties in the endeavor to eliminate it while saving the valuable metals associated with it in the ore. These difficulties compelled the smelters to impose heavy penalties on the zinc content in excess of certain percentages. Thus the end of many a mining operation was marked by its reaching a point where the ores could no longer stand the treatment charge necessarily imposed by the smelter, while

the transportation charge to an abundant supply of cheap fuel (usually natural gas), an essential for zinc reduction, made prohibitive any attempt to recover the metal, except in the case of ores very rich in zinc content. The presence of such refractory ores in some of the mines of the Anaconda Co. led to a careful study of the problem by its research department. Gratifying success has resulted from this study. An electrolytic process has been evolved and patented to the company which makes it possible at a satisfactory cost to extract a high percentage of the zinc content of such ores, while the other valuable metals are precipitated in the form of an easily reducible residue. Following experiments sufficiently long continued to demonstrate the success of the proposed method, a plant capable of producing 20,000 pounds of electrolytic zinc per day was built at Anaconda and has been in successful operation for several months. The product is very pure, its zinc content being about 99.9 per cent. The brand, which has been trade-marked "Anaconda Electric," finds ready sale at a considerable premium among manufacturers whose requirements demand zinc of the highest grade. This operation has been so successful that the company is now enlarging the plant at Anaconda sufficiently to make an output of 50,000 pounds of zinc per day. The product of this plant has been sold for a full year from the time when it will be in complete operation, at an estimated profit of over $4,000,000, and construction has been started upon a plant at Great Falls capable of making an output of 70,000,000 pounds of zinc per annum, which we hope to have in operation in the early autumn of this year. At a normal market price for zinc, this new product will hereafter form a very important and profitable part of the company's business.

The North Butte mine[1] in 1915 produced 378,105 dry tons of ore and from mine water 565 dry tons of copper precipitates. The first-class ore represented 12.5 per cent of the total and the second class 87.5 per cent. There were produced 19,235,285 pounds of fine copper, 940,631.66 ounces of silver, and 1,121.59 ounces of gold. The dividends paid to stockholders in 1915 amounted to $387,000. The following extract is taken from the company's annual report:

The important developments during the year were in the Sioux Chief vein on the 700 level, the Berlin vein on the 2,200 level, and the Edith May vein on the 2,800 and 3,000 levels, and the Jessie vein on the 2,800 level. The Sioux Chief vein promises to furnish a large amount of good-grade ore from the upper levels, and the Edith May and Jessie veins have shown high-grade ore in the bottom levels.

All of the construction work has been completed at the Granite Mountain shaft, and at the close of the year all of the hoisting was being done through that shaft.

An exhaust fan was installed at the Speculator shaft when hoisting ceased there, thereby greatly improving the ventilation throughout the entire mine.

The North Butte mine is now equipped with the largest electrical hoist in America at the Granite Mountain shaft, which is 3,000 feet deep. At the Davis Daly property its Colorado shaft has been sunk to the 2,500-foot level.

According to the annual report of the company[2] the Butte-Superior mine produced in 1915 zinc ores which yielded concentrates of zinc and lead with a little gold and silver, which, as sold to the smelters, was valued at $13,244,133. Dividends were paid stockholders during 1915 amounting to $4,908,115.13. The following extracts are taken from the company's report:

The principal item of development undertaken during the year was that of sinking the main shaft to the 1,900-foot level in preparation for opening up the Black Rock ore bodies on the 1,700 and 1,800 levels and developing the 1,600-foot level for active mining. * * * The 1,600-foot level has been developed for a length of about 700 feet, and the ore bodies disclosed both east and west of the shaft are fully as large as on any of the levels above, and they are also

[1] North Butte Mining Co. Ann. Rept. for year ending Dec. 31, 1915.
[2] Butte & Superior Mining Co. Fourth Ann. Rept. for year ending Dec. 31, 1915.

of substantially the same grade and character. Extensions of ore bodies were developed to the eastward on all of the working levels, from the 1,000 to the 1,500, considerably beyond points where commercial ore bodies were previously known to exist, thus disclosing in this direction important additions to known ore-bearing areas. * * * The developed ore reserves at the end of the year were approximately the same as at the beginning of it, or about 1,000,000 tons. * * *

The total ore mined for the year was 522,949 tons. The average cost of mining was $3.36 per ton, including all expenses for development work directly connected with mining and blocking out ore reserves, but exclusive of exploration work on outlying claims. * * *

The total ore milled during the year was 522,300 tons, the average rate for the last quarter having been about 50,000 tons per month, corresponding to 600,000 tons per annum. The ore milled contained an average of 17.02 per cent zinc and 7.63 ounces of silver. Both of these figures are slightly lower than the average for the previous year, the decrease being due principally to the fact that higher prices of zinc and lower costs of milling made it possible to profitably treat lower-grade ores. Mill recoveries averaged 92.21 per cent, or about 3.5 per cent more than for the previous year. For the last quarter of the year the average recovery was 95.07 per cent. The average milling cost was $1.75 per ton, as compared with $2.12 for the previous year.

Crude ore treated and concentrates produced at Butte-Superior mill in 1915.

Ore and product.	Quantity (tons).	Gold.		Silver.	
		Total content.	Average per ton.	Total content.	Average per ton.
		Ounces.		*Ounces.*	
Crude ore, milled	522,300	7,361.52	0.01409	3,985,090.18	7.6299
Zinc concentrate	152,897	6,163.68	.0403	3,385,164.19	22.140
Lead concentrate	5,274	286.03	.0542	178,218.38	33.792

Ore and product.	Copper.		Lead.		Zinc.	
	Total content.	Average per ton.	Total content.	Average per ton.	Total content.	Average per ton.
	Pounds.	*Per cent.*	*Pounds.*	*Per cent.*	*Pounds.*	*Per cent.*
Crude ore, milled	2,215,313	0.2121	12,667,964	1.2127	177,802,719	17.0211
Zinc concentrate	1,751,545	.573	7,485,489	2.448	163,956,791	53.616
Lead concentrate	40,665	.386	3,988,679	37.815	1,426,130	13.520

The total gross value of lead and zinc concentrates as sold to smelters was $13,244,133.03. The average total cost of actual mining and milling for the year was $5.11 per ton, this figure including all general charges and mine-development costs, as well as the cost of maintenance and all minor improvements in both mine and mill.

During 1915 the Clark interests have been developing their zinc properties in the north district. The Elm Orlu mine has been producing an average of 400 tons of ore per day, which has been treated at the company's Timber Butte mill. This mill has a capacity of 5,000 tons of concentrate per month, but has only been turning out about 4,000 tons on account of smelter contract being limited. At the East Butte Pittsmont smelter blast furnaces were reconstructed and their capacity increased to 900 tons daily. A new 400-ton oil flotation plant has been built to handle the tailing.

In 1915 the Dutton-Pittsmont mines[1] were operated from April 15 to the end of the year after being idle eight months, and the

[1] East Butte Copper Mining Co. Ann. Rept. for year ending Dec. 31, 1915.

smelter was started May 15. The ore produced was 150,911 tons, or more than twice the output of 1914. The average copper content was 4.28 per cent, as against 4.72 per cent the year previous. Mining per ton of ore cost $4.37, against $5.39 in 1914. The main working shaft was sunk 58 feet to a total depth of 1,828 feet. The following extract is taken from the company's annual report:

> Exploratory work on the higher levels has developed considerable new ore, hardly as much, however, as has been removed during the year. Exploratory work on the 1,500-foot level, now about one-third opened, has located other veins similar to those described in the last report. About 20 per cent of the ore has been derived from this level. While there have been opened up on this level several rich streaks of high-grade ore in the area so far explored, the veins on the whole are not as rich as those on the 600-foot, 800-foot, and 1,000-foot levels. They show, however, an improvement over the 1,200-foot level. * * *
>
> In considering future possibilities of the property account should be taken of the fact that the solid rock formation was not reached by the shaft until it had been sunk through 600 feet of overburden. The deepest level now opened, namely, the 1,500-foot, is therefore only 900 feet from the surface of the country rock. Nothing is yet known of the richness of veins below this point.
>
> In the Dutton property the 800-foot level has been opened by a total cross-cutting and drifting of 895 feet. This work makes available 200 feet of height on ore shoots in No. 6 vein that, as far as opened, compare favorably with those mined on higher levels.

GOLD, SILVER, COPPER, LEAD, AND ZINC IN NEVADA.

(MINES REPORT.)

By V. C. Heikes.

PRODUCTION.

From 5,118,620 tons of ore mined in Nevada in 1915 and from placer mines there was produced gold, silver, copper, lead, and zinc valued at $34,551,436, an increase in value of $5,250,594, as compared with $29,300,842 in 1914 from 4,522,022 tons of ore and from placer bullion. There were 799 producers of ore and bullion in 1915, of which 103 were placers, as against 620 lode producers and 111 placers in 1914. The value of the production of copper, $12,011,365, an increase of $3,900,167, was nearly 35 per cent of the total value. Zinc (spelter) also increased in value from $661,992 in 1914 to $3,022,680 in 1915. The largest part of the total increase in 1915 was in the value of zinc and copper. Lead also added considerably to the total value. Gold decreased from $11,481,188 in 1914 to $11,404,300 in 1915, and silver from $8,546,887 to $7,331,139. The placer production of gold increased from $377,262 in 1914 to $395,319 in 1915. Twelve mining companies paid dividends in 1915 amounting to $8,161,692.

Mine production of metals in Nevada, 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.[a]
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	731	4,522,022	$11,481,188	15,455,491	60,986,450	12,809,655	12,980,232	$29,300,842
1915	799	5,118,620	11,404,300	14,459,840	68,636,370	16,637,277	24,376,450	34,551,436
Increase or decrease, 1915	.....	+596,598	−76,888	−995,651	+7,649,920	+3,827,622	+11,396,218	+5,250,594
Total, 1904–1915	.....	33,944,213	145,712,435	131,132,892	515,957,354	108,294,061	81,236,515	306,722,214

[a] Includes placer production.

ORE.

In 1915 Nevada's mines produced 5,118,620 tons of ore, an increase of 596,598 tons, compared with the production of 1914. The average total metallic value per ton was $6.67, against $6.40 in 1914, but the gold and silver value per ton decreased from $4.34 in 1914 to $3.58

in 1915. The largest decrease in production of ore was in Lyon, Storey, and Esmeralda counties. The output of dry or siliceous ores increased from 1,594,486 tons in 1914 to 1,812,653 tons in 1915. Under this classification is included 959,304 tons of low-grade siliceous gold ores, averaging $7.19 in gold and 0.62 ounce of silver per ton, and carrying small quantities of copper and lead. Gold and silver mixed ores, dry or siliceous in character, aggregated 16,558 tons and averaged per ton $6.71 in gold and 8.21 ounces of silver. The output of siliceous silver ores in 1915 amounted to 836,791 tons, mined by 112 producers and averaging per ton $3.14 in gold and 15.63 ounces of silver, and carrying small quantities of copper and lead, as against 676,573 tons mined in 1914 by 100 producers, whose ore averaged per ton $4.47 in gold and 20.37 ounces of silver. A total of 117,038 tons of oxidized iron manganese ore, which was produced entirely in the Pioche district, is included in the silver ore. This ore contained lead and small quantities of gold and silver and was particularly valuable as flux.

The production of copper ore by 129 operators amounted to 3,247,140 tons and contained 63,043.85 ounces of gold, 244,643 ounces of silver, 68,435,787 pounds of copper, and 58,022 pounds of lead, the value per ton averaging $4.13. The output of lead ores decreased from 16,088 tons in 1914 to 15,508 tons in 1915. Lead ore of smelting grade amounted to 7,447 tons. In this smelting ore the oxidized ore, largely carbonates, decreased in quantity from 8,083 tons in 1914 to 5,788 tons in 1915, which averaged $6.13 in gold, 22.21 ounces of silver, 2.55 pounds of copper, 507.90 pounds of lead, and $41.71 in total value per ton. The smelting sulphide ores of lead amounted to 1,659 tons and averaged $1.46 in gold, 25.86 ounces of silver, 10.52 pounds of copper, 849.83 pounds of lead, and $56.35 in total value per ton. Zinc ores of shipping grade increased from 9,440 tons in 1914 to 24,816 tons in 1915. The oxidized or carbonate zinc ores amounted to 20,437 tons, from which was recovered an average of 655.98 pounds of zinc per ton. The zinc sulphide ores amounted to 4,379 tons and produced $2.63 in gold, 7.88 ounces of silver, 20.21 pounds of lead, and 609.19 pounds of zinc per ton. Production of copper-lead ores decreased from 3,762 tons in 1914 to 1,485 tons in 1915. Of this quantity, 1,448 tons were shipped to smelters. Of these direct shipments, 1,083 tons were oxidized or carbonate copper-lead ores, averaging 31 cents in gold, 21.81 ounces of silver, 87.81 pounds of copper, 230.01 pounds of lead, and $37.54 in total average value per ton; and 365 tons were sulphide copper-lead ores, containing $5.77 in gold, 28.61 ounces of silver, 89.99 pounds of copper, 496.83 pounds of lead, and $59.38 in total average value per ton. There were 16,940 tons of lead-zinc ore produced, the largest part of which, or 16,839 tons, was concentrated into a lead-zinc concentrate. Only 101 tons of lead-zinc ore was of shipping grade.

The output of milling ores was 4,819,702 tons, of which 1,620,289 tons were treated by amalgamation and cyanidation and the remainder, 3,199,413 tons, by concentration alone. The ores and tailings treated by cyanidation—1,408,560 tons of the former and 61,338 tons of the latter—produced an average per ton of $5.20 in gold and 8.54 ounces of silver. The ores amalgamated, 211,729 tons, yielded bullion averaging per ton $6.86 in gold and 0.218 ounce of silver.

Mine production of metals in Nevada in 1915.

Source of production.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc. (spelter).
		Short tons.	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*
Placers	103	.....	19,123.55	6,030	.....	.....	.....
Dry or siliceous ore	417	1,812,653	466,358.56	13,808,912	11,688	7,183,878	.....
Copper ore	129	3,247,140	63,043.85	244,643	68,435,787	58,022	.....
Lead ore	140	15,508	2,463.69	238,420	51,303	5,222,233	.....
Zinc ore	30	24,816	558.01	41,295	.....	621,987	16,073,949
Copper-lead ore	16	1,485	118.52	34,690	132,154	435,135	.....
Lead-zinc ore	5	16,940	.63	85 239	.....	3,098,445	8,259,850
Copper-lead-zinc ore	1	78	16.20	611	5,438	17,577	42,651
		5,118,620	551,683.01	14,459,840	68,636,370	16,637,277	24,376,450

Ore sold or treated in Nevada in 1915, in short tons.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-lead-zinc ore.	Total.
Churchill	123,924	41	26	.....	.....	.....	.....	123,991
Clark	13,976	1,251	1,134	19,464	113	16,859	.....	52,797
Douglas	56	90	.....	.....	.....	.....	.....	146
Elko	15,996	1,501	401	1,083	894	.....	.....	19,875
Esmeralda	441,002	28,973	218	.....	.....	.....	.....	470,193
Eureka	103,903	.....	5,231	32	73	81	.....	109,320
Humboldt	56,128	331	213	.....	11	.....	.....	56,683
Lander	17,361	14	325	.....	.....	.....	.....	17,700
Lincoln	121,621	3,136	990	4,237	168	.....	.....	130,152
Lyon	12,034	4,736	.....	.....	.....	.....	.....	16,770
Mineral	187,298	2,857	1,084	.....	17	.....	.....	191,256
Nye	630,774	.....	213	.....	.....	.....	.....	630,987
Ormsby	454	53	.....	.....	.....	.....	.....	507
Storey	85,144	.....	.....	.....	.....	.....	.....	85,144
Washoe	2,020	51	3,047	.....	.....	.....	.....	5,118
White Pine	962	3,204,106	2,626	.....	209	.....	78	3,207,981
	[a] 1,812,653	3,247,140	15,508	24,816	1,485	16,940	78	5,118,620
Average value per ton in gold and silver	$9.18	$0.44	$11.08	$1.31	$13.49	$2.55	$8.27	$3.58

[a] Includes 959,304 tons of gold ore, 16,558 tons of gold and silver ore, and 836,791 tons of silver ore. The latter includes 117,038 tons of oxidized iron ore.

GOLD.

The mine production of gold was valued at $11,404,300 in 1915, a decrease of $76,888, as compared with 1914. Esmeralda County is credited with the largest production of gold, amounting to $4,689,260, against $5,226,367 in 1914. Nearly all of this output was from the Goldfield district, which produced $315,860 less than in 1914. The counties having substantial increase in gold were Mineral and White Pine, followed by Humboldt and Clark. The largest decrease was in Esmeralda and Nye counties. Placer gold was produced in greatest quantity in Nye, Lander, and Eureka counties. The value of the placer gold was $395,319 against $377,262 in 1914. Ore was milled in 1915 by amalgamation in 12 counties and by cyanidation in 14 counties. From these two methods of treatment $9,101,502 in gold was produced from 1,620,289 tons of ore and 61,338 tons of old tailings. The total average gold recovery from ore and tailings was $5.41 a ton. The gold extracted by amalgamation averaged $6.86 a ton of ore treated, as against $5.69 a ton in 1914; and by

cyanidation it averaged $5.20 a ton of ore and tailings treated, as against $6.18 in 1914. From copper, lead, zinc, lead-zinc, and iron sulphide concentrates 40,089.01 ounces of gold were produced, against 41,686.38 ounces in 1914. The gold in siliceous concentrates was 12,986.79 ounces in 1915, against 21,028. 24 ounces in 1914 and was principally from iron sulphide concentrates; the copper concentrates contained 26,530 ounces against 20,527.80 ounces in 1914; and the lead concentrates, 572.22 ounces, against 130.34 ounces in 1914.

Mine production of gold in Nevada in 1915, in fine ounces.

County.	Placers.	Deep mines.							Total.
		Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-lead-zinc ore.	
Churchill	.....	13,864.55	0.74	1.11	.....	.....	.....	.....	13,866.40
Clark	.....	6,618.93	1,389.41	.98	.....	100.22	.....	.....	8,109.54
Douglas	66.66	30.24	.....	.....	.....	.....	.....	.....	96.90
Elko	17.61	7,096.74	7.89	3.51	.....	8.02	.....	.....	7,133.77
Esmeralda	4.11	192,631.81	34,180.19	26.84	.....	.....	.....	.....	226,842.95
Eureka	449.79	14,464.72	.....	1,243.41	.....	.97	0.63	.....	16,159.52
Humboldt	427.44	38,644.13	40.39	37.03	.....	2.98	.....	.....	39,151.97
Lander	7,777.05	972.50	15.46	172.46	.....	.....	.....	.....	8,937.47
Lincoln	.....	1,189.17	49.60	156.05	558.01	5.24	.....	.....	1,958.07
Lyon	7.98	4,111.70	17.11	.....	.....	.....	.....	.....	4,136.79
Mineral	344.82	35,344.21	44.40	674.76	.....	.....	.....	.....	36,408.19
Nye	9,904.49	133,076.40	.....	33.99	.....	.....	.....	.....	143,014.88
Ormsby	.....	67.34	.....	.....	.....	.....	.....	.....	67.34
Storey	.....	14,463.64	.....	.....	.....	.....	.....	.....	14,463.64
Washoe	7.74	1,301.32	5.00	1.01	.....	.....	.....	.....	1,315.07
White Pine	115.86	2,481.16	27,293.66	112.54	.....	1.09	.....	16.20	30,020.51
	19,123.55	[a] 466,358.56	63,043.85	2,463.69	558.01	118.52	.63	16.20	551,683.01

[a] Includes 333,907.39 ounces from gold ore, 5,372.05 ounces from gold and silver ore, and 127,079.12 ounces from silver ore.

SILVER.

The mine production of silver in Nevada in 1915 was 14,459,840 ounces, valued at $7,331,139, a decrease of 995,651 ounces in quantity and of $1,215,748 in value, as compared with the output in 1914. Nye County was again the largest producer, with 10,220,018 ounces, against 11,424,769 ounces in 1914; and Churchill County produced 1,620,573 ounces in 1915, against 1,545,926 ounces in 1914. The largest producer of silver was the Belmont mine, at Tonopah, in Nye County, followed by the Tonopah Mining Co. and the Tonopah Extension mine. Milling plants using amalgamation and cyanidation in the extraction of the precious metals from ore produced 12,504,864 ounces of silver, of which 46,103 ounces were recovered by amalgamation and 12,458,761 ounces by cyanidation. Nye County was credited with the largest production of silver by cyanidation—9,608,962 ounces from ores treated principally in the Tonopah district. In Churchill County, 1,577,167 ounces of silver were recovered by cyanidation. Concentrates from milling plants yielded 859,587 ounces of silver, against 1,721,348 ounces in 1914. The dry or siliceous ores milled produced 646,303 ounces from concentrates in 1915, against 1,480,206 ounces in 1914. Lead concentrates contained 107,276 ounces of silver, or an average per ton of 39.89 ounces,

against 139,562 ounces, or an average per ton of 48.73 ounces in 1914; lead-zinc concentrates contained 2.76 ounces per ton, against 3.27 ounces per ton in 1914.

Mine production of silver in Nevada in 1915, in fine ounces.

County.	Placers.	Deep mines.							Total.
		Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-lead-zinc ore.	
Churchill	.....	1,619,675	335	563	.....	.....	.....	.....	1,620,573
Clark	.....	59,051	2,381	6,575	6,809	957	84,976	.....	160,749
Douglas	10	908	.....	.....	.....	.....	.....	.....	918
Elko	8	20,856	9,486	16,625	.....	18,332	.....	.....	65,307
Esmeralda	2	131,595	117,074	4,509	.....	.....	.....	.....	253,180
Eureka	40	129,137	.....	51,460	.....	5,683	263	.....	186,583
Humboldt	113	729,295	789	9,884	.....	479	.....	.....	740,560
Lander	1,189	101,175	12	28,754	.....	.....	.....	.....	131,130
Lincoln	.....	356,984	36,243	27,038	34,486	3,074	.....	.....	457,825
Lyon	2	15,679	1,132	.....	.....	.....	.....	.....	16,813
Mineral	181	260,355	7,041	24,441	.....	224	.....	.....	292,242
Nye	4,462	10,209,671	.....	5,885	.....	.....	.....	.....	10,220,018
Ormsby	.....	1,237	.....	.....	.....	.....	.....	.....	1,237
Storey	.....	156,645	.....	.....	.....	.....	.....	.....	156,645
Washoe	2	734	228	42,162	.....	.....	.....	.....	43,126
White Pine	21	15,915	69,922	20,524	.....	5,941	.....	611	112,934
	6,030	[a] 13,808,912	244,643	238,420	41,295	34,690	85,239	611	14,459,840

[a] Includes 591,743 ounces from gold ore, 136,036 ounces from gold and silver ore, and 13,081,133 ounces from silver ore.

COPPER.

Copper produced from ores mined and treated in 1915 aggregated 68,636,370 pounds, valued at $12,011,365, an increase for the year of 7,649,920 pounds in quantity and of $3,900,167 in value. The Nevada Consolidated mines at Ely, in White Pine County, produced a large share of the State total, followed by the mines in the Goldfield district of Esmeralda County. White Pine County mines produced 64,682,966 pounds in 1915, against 51,176,830 pounds in 1914; Esmeralda County mines, 1,693,450 pounds, against 1,072,408 pounds; and Lyon County mines, 700,874 pounds, against 7,274,329 pounds in 1914. Concentrates recovered at milling plants in Nevada contained 62,997,281 pounds of copper, against 50,366,650 pounds in 1914. Of the output in 1915, copper concentrates contained 62,992,883 pounds, against 50,350,664 pounds in 1914. Crude ore shipped to smelters contained 5,611,836 pounds of copper, against 10,551,000 pounds in 1914. The crude copper ores smelted contained 5,437,690 pounds, of which 3,509,463 pounds were produced from sulphide ores and 1,928,227 pounds from oxidized ores. Lead ores of smelting grade produced 32,240 pounds of copper—17,456 pounds from sulphide ores and 14,784 pounds from oxidized ores. Copper-lead ores shipped contained 127,947 pounds of copper, of which the oxidized ores contained 95,098 pounds and the sulphide ores 32,849 pounds.

Mine production of copper in Nevada in 1915, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Copper-lead ore.	Copper-lead-zinc ore.	Total.
Churchill	1,271	17,896	.....	.....	.....	19,167
Clark	531	291,668	.....	9,128	.....	301,327
Douglas	.....	5,214	.....	.....	.....	5,214
Elko	.....	329,606	2,121	81,773	.....	413,500
Esmeralda	69	1,692,428	953	.....	.....	1,693,450
Eureka	1,220	.....	5,638	8,955	.....	15,813
Humboldt	1,165	48,975	637	585	.....	51,362
Lander	119	1,920	4,721	.....	.....	6,760
Lincoln	323	269,491	15,073	12,296	.....	297,183
Lyon	.....	700,874	.....	.....	.....	700,874
Mineral	684	431,276	102	1,522	.....	433,584
Nye	1,979	.....	366	.....	.....	2,345
Ormsby	.....	7,176	.....	.....	.....	7,176
Storey	531	.....	.....	.....	.....	531
Washoe	.....	5,118	.....	.....	.....	5,118
White Pine	3,796	64,634,145	21,692	17,895	5,438	64,682,966
	[a] 11,688	68,435,787	51,303	132,154	5,438	68,636,370

[a] Includes 7,112 pounds from gold ore and 4,576 pounds from silver ores.

LEAD.

The mine production of lead in Nevada in 1915 was 16,637,277 pounds, valued at $781,952, against 12,809,655 pounds, valued at $499,577, in 1914. Lincoln County mines continued to have the largest output, 7,695,155 pounds in 1915, followed by Clark County mines, with 4,655,985 pounds, and by White Pine County mines, with 1,603,740 pounds. About 22 per cent of the output of lead was derived from concentrates and 78 per cent from crude ores shipped directly to smelters. Lead concentrates (carbonates and sulphides) shipped to the smelters from the milling plants of the State contained 2,264,706 pounds, against 2,798,176 pounds in 1914, and averaged 42.10 per cent of lead in 1915, against 49.69 per cent in 1914; lead-zinc concentrates contained 1,366,400 pounds, averaging 4.91 per cent of lead in 1915, against an average of 4.60 per cent in 1914. The total crude ore of shipping grade contained 12,657,269 pounds of lead, against 8,794,246 pounds in 1914. The iron manganese ores, classified under dry or siliceous ore, contained most of the lead, or 7,163,179 pounds. Oxidized lead ore contained 2,939,773 pounds of lead, against 2,129,828 pounds in 1914. The sulphide lead ores contained 1,409,867 pounds of lead, against 944,766 pounds in 1914. Zinc ores shipped produced 621,987 pounds of lead, of which 533,486 pounds were from oxidized and 88,501 pounds were from sulphide ores. Copper-lead ores of shipping grade produced 430,448 pounds of lead, of which 249,103 pounds were from oxidized carbonate ores and 181,345 pounds were from the sulphides. The oxidized lead-zinc ores shipped produced 16,416 pounds of lead, and copper-lead-zinc oxidized ores shipped contained 17,577 pounds of lead.

Mine production of lead in Nevada in 1915, in dry pounds.

County.	Dry or siliceous ore.	Copper ore.	Lead ore.	Zinc ore.	Copper-lead ore.	Lead-zinc ore.	Copper-lead-zinc ore.	Total.
Churchill	2,406	.....	22,168	.....	.....	.....	.....	24,574
Clark	1,897	720	998,008	533,486	33,845	3,088,029	.....	4,655,985
Elko	.....	273	249,026	.....	187,549	.....	.....	436,848
Esmeralda	2,664	.....	104,555	.....	.....	.....	.....	107,219
Eureka	14,842	.....	1,222,625	.....	51,202	10,416	.....	1,299,085
Humboldt	6,630	1,475	89,470	.....	3,513	.....	.....	101,088
Lander	3,963	.....	72,723	.....	.....	.....	.....	76,686
Lincoln	7,133,834	55,464	382,195	88,501	35,161	.....	.....	7,695,155
Mineral	794	40	209,461	.....	10,752	.....	.....	221,047
Nye	1,002	.....	200,980	.....	.....	.....	.....	201,982
Storey	4,873	.....	.....	.....	.....	.....	.....	4,873
Washoe	.....	.....	208,995	.....	.....	.....	.....	208,995
White Pine	10,973	50	1,462,027	.....	113,113	.....	17,577	1,603,740
	[a] 7,183,878	58,022	5,222,233	621,987	435,135	3,098,445	17,577	16,637,277

[a] Includes 33,603 pounds from gold ore and 7,150,275 ounces from silver ore.

ZINC.

The recoverable mine production of zinc from zinc, lead-zinc, and copper-lead-zinc ores mined in Nevada in 1915 is calculated at 24,376,450 pounds, valued at $3,022,680, against 12,980,232 pounds, valued at $661,992, in 1914. Clark County is credited with the largest part of the output, or 21,061,182 pounds of zinc, from the Yellow Pine district. The remainder of the output was from the Pioche district, in Lincoln County, and from Elko, Eureka, and White Pine counties. Lead-zinc concentrates amounted to 13,915 tons and averaged 28.85 per cent zinc. The shipments of zinc ore to the smelters amounted to 24,816 tons and consisted of 20,437 tons of carbonate and silicate ores and 4,379 tons of sulphide ore. The zinc ore shipped averaged 32.38 per cent of zinc and the lead-zinc ore 28.22 per cent.

Mine production of zinc in Nevada in 1915, in dry pounds.

County.	Zinc ore.	Lead-zinc ore.	Copper-lead-zinc ore.	Total.
Clark	12,847,468	8,213,714	.....	21,061,182
Elko	631,819	.....	.....	631,819
Eureka	14,917	46,136	.....	61,053
Lincoln	2,579,745	.....	.....	2,579,745
White Pine	.....	.....	42,651	42,651
	16,073,949	8,259,850	42,651	24,376,450

Zinc-producing ores and concentrates from Nevada mines, sold in 1915.

County.	Classification.	Quantity.	Average zinc assay of ore and concentrate.[a]
		Short tons.	*Per cent.*
Elko and Lincoln	Sulphide zinc ore	4,379	37.10
Clark, Elko, and Eureka	Oxidized zinc ore	20,437	38.58
Clark and Eureka	Oxidized lead-zinc ore	101	32.71
White Pine	Oxidized copper-lead-zinc ore.	78	33.34
Clark	Zinc concentrates	335	30.50
Do	Lead-zinc concentrates	13,915	33.94
		39,245	36.68

[a] Actual assay content.

MINING INDUSTRY.

Except for a threatened labor strike at Ely, the conditions of labor and wages were normal in Nevada throughout 1915. Many mine operators took advantage of the higher prices paid for zinc, copper, and lead to work properties producing those metals. Ore buyers were active. The principal one, the Western Ore Purchasing Co., of Reno, reopened its sampler at Goldfield, thus affording a quicker and more convenient market for the small shippers of gold ores. It has been purchasing ores since 1904, first at Reno, then establishing samplers at Millers, Goldfield, and Hazen, where the ores purchased and sampled are mixed in carload lots to suit the purchaser. During 1915 and part of 1916, according to a recent article,[1] the approximate shipments of ore to Utah and California smelters were 150 tons a day of 6 per cent copper ore from Luning; 500 tons a month of silver ore averaging $25 per ton from Candaleria; 150 tons a month of silver-lead ores from Marietta, near Candaleria; 60 cars a month of copper ore from Mason Valley, including Yerington and other places; 4 cars of concentrates a month from Belmont; 15 cars a month from Schurz, including the shipments of the Yerington Mountain Copper Co.; 2 cars of gold and silver ore a month from Rawhide; occasional shipments of silver-lead ore from Hawthorne; 3,000 tons of gold ore from Goldfield a month; 1 car of high-grade gold ore from Seven Troughs and Lovelock; 8 cars a month of copper ore from Golconda; and 8 cars a month of copper-lead and silver ore from Battle Mountain. Motor trucks were in use throughout various parts of the State, but unless roads were good the costs of hauling ore and supplies were not much less than under former conditions of hauling by horse and mule teams.

The ores were milled at 92 plants, against 82 plants in 1914. Most of these were operated for short periods each year. Thirty-eight plants used the amalgamation process, against 31 in 1914; 4, both amalgamation and concentration, against 8 in 1914; 5 amalgamation and cyanidation, against 3 in 1914. Twelve plants used concentration, of which 2 were equipped with the oil flotation process, against 7 in 1914. Twenty-seven straight cyanidation mills were operated in 1915, against 25 in 1914; and 5 mills used cyanidation and concentra-

[1] Min. Eng. World, Aug. 26, 1916, p. 362.

tion, against 8 in 1914. One plant, in Douglas County, equipped for leaching ores, was active in 1915.

During 1915 there were consumed at these mills 4,367 pounds of quicksilver and 3,063,606 pounds of potassium and sodium cyanide, a consumption of 0.038 pound of mercury per ounce of gold and silver bullion produced, and of 0.021 pound of mercury per ton of ore treated. The consumption of cyanide was 0.239 pound per ounce of gold and silver bullion produced and 2.07 pounds per ton of ore and tailings treated.

The total value of the bullion recovered from ore and tailings was $15,441,468, against $15,785,513 in 1914.

Gold and silver produced from Nevada mills in 1915.

County.	Ore.	Bullion recovered from ore by—				Total value.
		Amalgamation.		Cyanidation.		
		Gold.	Silver.	Gold.	Silver.	
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	
Churchill	122,427	.....	.....	[a] 13,475.77	[a] 1,577,167	$1,078,193
Clark	[b] 11,818	2,217.39	516	[c] 4,175.16	[c] 57,649	161,636
Douglas	40	7.21	2	.....	.....	150
Elko	[d] 15,417	4,566.19	3,850	[e] 2,326.34	[e] 14,125	151,594
Esmeralda	437,192	6,716.93	4,701	181,787.10	121,301	3,960,607
Eureka	103,528	.....	.....	14,026.00	106,081	343,726
Humboldt	[f] 53,113	26,397.34	20,141	[g] 4,584.05	[g] 543,620	926,269
Lander	1,030	376.05	200	[h] 472.67	[h] 50,014	43,004
Lincoln	[i] 2,468	.....	.....	46.45	12,222	7,157
Lyon	7,221	3,360.28	2,444	[j] 751.40	[j] 13,235	92,945
Mineral	[k] 155,431	941.44	507	[l] 32,049.97	[l] 228,131	797,912
Nye	[m] 629,317	20,553.49	9,869	[n] 107,811.05	[n] 9,608,962	7,530,278
Ormsby	.....	.....	.....	[o] 67.32	[o] 1,237	2,019
Storey	[p] 79,159	3,717.88	3,080	[q] 8,468.27	[q] 125,013	316,853
Washoe	2,020	1,300.34	730	1.00	4	27,273
White Pine	108	88.06	63	.....	.....	1,852
	1,620,289	70,242.60	46,103	370,042.55	12,458,761	15,441,468

[a] Includes bullion from 1,418 tons of old tailings, which also yielded 133 tons of concentrates.
[b] Also yielded 42 tons of concentrates.
[c] Includes bullion from 2,000 tons of old tailings.
[d] Also yielded 3 tons of concentrates.
[e] Includes bullion from 500 tons of old tailings.
[f] Also yielded 889 tons of concentrates.
[g] Includes bullion from 60 tons of old tailings.
[h] Includes bullion from 16,000 tons of old tailings.
[i] Also yielded 77 tons of concentrates.
[j] Includes bullion from 4,813 tons of old tailings.
[k] Also yielded 1 ton of concentrates.
[l] Includes bullion from 31,148 tons of old tailings.
[m] Also yielded 1,399 tons of concentrates.
[n] Includes bullion from 410 tons of old tailings.
[o] Produced from 454 tons of old tailings.
[p] Also yielded 251 tons of concentrates.
[q] Includes bullion from 4,535 tons of old tailings.

Mills equipped for the concentration of low-grade ore treated 3,199,413 tons, or more than 62 per cent of the total ore sold or treated. The concentrates produced aggregated 458,162 tons and contained $828,713 in gold, 859,587 ounces of silver, 62,997,281 pounds of copper, 3,651,805 pounds of lead, and 8,202,834 pounds of zinc (spelter), valued in all at $13,477,834, or a total average value per ton of $29.42.

Mine production of metals from Nevada concentrates in 1915.

By counties.

	Ore to concentrating mills.	Concentrates.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value of concentrates.
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
Churchill	.....	133	228.99	35,556	1,271	.....	.....	$22,983
Clark	17,385	16,091	139.89	86,426	531	3,262,094	8,202,834	1,217,272
Elko	.....	3	102.36	1,189	.....	.....	.....	2,719
Esmeralda	94	31	5.40	140	.....	36,100	.....	1,880
Eureka	3,000	500	567.00	16,800	1,900	60,000	.....	23,392
Humboldt	20	894	6,571.23	24,513	123	6,366	.....	148,588
Lincoln	4	78	66.31	6,602	.....	14,038	.....	5,378
Lyon	1,000	180	.....	136	42,924	.....	.....	7,580
Mineral	.....	1	7.41	11	.....	.....	.....	159
Nye	3	1,419	3,736.06	552,630	.....	.....	.....	357,415
Storey	1,402	386	2,129.14	25,841	531	4,873	.....	57,436
Washoe	3,044	304	.70	41,766	.....	208,633	.....	30,995
White Pine	3,173,461	438,142	26,534.52	67,977	62,950,001	59,701	.....	11,602,037
	3,199,413	458,162	40,089.01	859,587	62,997,281	3,651,805	8,202,834	13,477,834

By kinds of concentrates.

Dry or siliceous	2,956	12,986.79	646,303	2,333	20,699	.....	$597,517
Copper	438,267	26,530.00	67,608	62,992,883	.....	.....	11,606,456
Lead	2,689	572.22	107,276	2,065	2,264,706	.....	173,020
Zinc	335	.....	.....	.....	.....	173,734	21,543
Lead-zinc	13,915	.....	38,400	.....	1,366,400	8,029,100	1,079,298

Smelting operations were carried on only at the Steptoe plant of the Nevada Consolidated Co., at McGill. The Mason Valley smelter, at Thompson, was idle. At the property of the Nevada-Douglas Copper Co., the 250-ton leaching plant was expected to be ready to begin production the first part of 1916.

Mine production of metals from Nevada crude ore shipped to smelters in 1915.

By counties.

	Crude ore to smelters.						Total value.
	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	
	Short tons.	*Fine oz.*	*Fine oz.*	*Pounds.*	*Pounds.*	*Pounds.*	
Churchill	146	161.64	7,850	17,896	24,574	.....	$11,609
Clark	21,594	1,577.10	16,158	300,796	1,393,891	12,858,348	1,753,381
Douglas	16	23.03	906	.....	.....	.....	935
Elko	3,945	121.06	45,874	411,081	435,341	631,819	196,506
Esmeralda	32,907	38,329.41	127,036	1,693,450	71,119	.....	1,156,443
Eureka	2,792	1,116.73	63,662	13,913	1,239,085	61,053	123,604
Humboldt	3,488	1,171.84	152,147	51,239	93,616	.....	114,730
Lander	670	311.70	79,727	6,760	76,686	.....	51,653
Lincoln	125,645	1,682.86	419,669	297,183	7,681,117	2,579,745	980,468
Lyon	3,736	17.13	996	657,950	.....	.....	115,999
Mineral	4,677	3,064.55	63,412	433,584	221,047	.....	181,766
Nye	699	932.50	27,584	2,345	201,982	.....	43,165
Ormsby	53	.....	.....	7,176	.....	.....	1,256
Storey	48	148.35	2,711	.....	.....	.....	4,441
Washoe	54	5.29	624	5,118	362	.....	1,339
White Pine	32,938	3,173.26	36,797	1,713,345	1,218,449	42,651	446,644
	233,408	51,836.45	1,045,153	5,611,836	12,657,269	16,173,616	5,183,939

By kinds of ore.

Dry or siliceous	126,761	12,797.04	620,210	8,521	7,163,179	.....	$917,146
Copper	72,757	36,513.85	177,035	5,437,690	58,022	.....	1,798,888
Lead	7,447	1,832.51	171,440	32,240	4,349,640	.....	334,876
Zinc	24,816	558.00	41,295	.....	621,987	16,073,949	2,054,874
Copper-lead	1,448	118.21	34,059	127,947	430,448	.....	62,333
Lead-zinc	101	.64	503	.....	16,416	57,016	8,110
Copper-lead-zinc	78	16.20	611	5,438	17,577	42,651	7,712

PRODUCTION BY COUNTIES.

GENERAL STATEMENT.

The following tables show the State output, by counties, in 1915, the production of each metal, and the total value; also the production of ore, the average value per ton, by counties, for 1914 and 1915, and the statistics of placer mines. The tables are followed by a review of the mining industry for each county and each producing mining district.

Mine production of metals in Nevada in 1915.

County.	Gold.					Silver.	
	Placers.		Deep mines.		Total value.	Quantity.	Value.
	Quantity.	Value.	Quantity.	Value.			
	Fine ounces.		*Fine ounces.*			*Fine ounces.*	
Churchill			13,866.40	$286,644	$286,644	1,620,573	$821,630
Clark			8,109.54	167,639	167,639	160,749	81,500
Douglas	66.66	$1,378	30.24	625	2,003	918	465
Elko	17.61	364	7,116.16	147,104	147,468	65,307	33,111
Esmeralda	4.11	85	226,838.84	4,689,175	4,689,260	253,180	128,362
Eureka	449.79	9,298	15,709.73	324,749	334,047	186,583	94,598
Humboldt	427.44	8,836	38,724.53	800,507	809,343	740,560	375,464
Lander	7,777.05	160,766	1,160.42	23,988	184,754	131,130	66,483
Lincoln			1,958.07	40,477	40,477	457,825	232,117
Lyon	7.98	165	4,128.81	85,350	85,515	16,813	8,524
Mineral	344.82	7,128	36,063.37	745,496	752,624	292,242	148,167
Nye	9,904.49	204,744	133,110.39	2,751,636	2,956,380	10,220,018	5,181,549
Ormsby			67.34	1,392	1,392	1,237	627
Storey			14,463.64	298,990	298,990	156,645	79,419
Washoe	7.74	160	1,307.33	27,025	27,185	43,126	21,865
White Pine	115.86	2,395	29,904.65	618,184	620,579	112,934	57,258
	19,123.55	395,319	532,559.46	11,008,981	11,404,300	14,459,840	7,331,139

County.	Copper.		Lead.		Zinc (spelter).		Total value.
	Quantity.	Value.	Quantity.	Value.	Quantity.	Value.	
	Pounds.		*Pounds.*		*Pounds.*		
Churchill	19,167	$3,354	24,574	$1,155			$1,112,783
Clark	301,327	52,732	4,655,985	218,832	21,061,182	$2,611,587	3,132,290
Douglas	5,214	913					3,381
Elko	413,500	72,363	436,848	20,532	631,819	78,345	351,819
Esmeralda	1,693,450	296,354	107,219	5,039			5,119,015
Eureka	15,813	2,767	1,299,085	61,057	61,053	7,571	500,040
Humboldt	51,362	8,988	101,088	4,751			1,198,546
Lander	6,760	1,183	76,686	3,604			256,024
Lincoln	297,183	52,007	7,695,155	361,672	2,579,745	319,888	1,006,161
Lyon	700,874	122,653					216,692
Mineral	433,584	75,877	221,047	10,389			987,057
Nye	2,345	410	201,982	9,493			8,147,832
Ormsby	7,176	1,256					3,275
Storey	531	93	4,873	229			378,731
Washoe	5,118	896	208,995	9,823			59,769
White Pine	64,682,966	11,319,519	1,603,740	75,376	42,651	5,289	12,078,021
	68,636,370	12,011,365	16,637,277	781,952	24,376,450	3,022,680	34,551,436

Production from deep mines in Nevada in 1914 and 1915.

County.	Ore sold or treated.		Number of deep mines producing.		Average value per ton.[a]		Average value per ton in gold and silver.[a]	
	1915	Increase or decrease.	1914	1915	1914	1915	1914	1915
	Short tons.	*Short tons.*						
Churchill	123,991	+ 9,220	19	13	$10.24	$8.97	$10.23	$8.94
Clark	52,797	+ 24,987	27	54	34.41	59.33	5.85	4.72
Douglas	146	+ 121	1	3	15.48	13.68	15.48	7.43
Elko	19,875	+ 8,211	38	75	22.56	17.68	16.57	9.07
Esmeralda	470,193	− 13,802	48	70	11.28	10.89	10.98	10.25
Eureka	109,320	+ 32,994	33	38	5.32	4.49	5.10	3.84
Humboldt	56,683	+ 26,114	78	96	29.62	20.99	29.43	20.75
Lander	17,700	+ 11,227	15	23	20.05	5.35	19.49	5.08
Lincoln	130,152	+ 38,820	20	19	7.23	7.73	3.10	2.09
Lyon	16,770	− 95,946	47	41	9.20	12.91	.61	5.60
Mineral	191,256	+115,099	99	93	6.79	5.12	6.33	4.67
Nye	630,987	+ 1,017	84	72	15.05	12.58	15.05	12.57
Ormsby	507	+ 467	4	4	10.70	6.46	10.70	3.98
Storey	85,144	− 18,262	36	23	5.69	4.45	5.69	4.44
Washoe	5,118	− 177	45	22	14.60	11.65	11.93	9.55
White Pine	3,207,981	+456,508	26	50	2.64	3.76	.15	.21
	5,118,620	+596,598	620	696	6.40	6.67	4.34	3.58

[a] Value per ton, placer product excluded.

Production from placer mines in Nevada in 1914 and 1915.

County.	1914						1915					
	Mines.			Gold.	Silver.	Total value.	Mines.			Gold.	Silver.	Total value.
	Hydraulic.	Drift.	Dredge.				Hydraulic.	Drift.	Dredge.			
					Fine ounces.						*Fine ounces.*	
Douglas	1	.....	.....	$1,120	7	$1,124	2	.....	.....	$1,378	10	$1,383
Elko	7	.....	.....	3,197	47	3,223	3	.....	.....	364	8	368
Esmeralda	2	.....	.....	117	2	118	1	.....	.....	85	2	86
Eureka	12	.....	.....	8,486	25	8,500	8	.....	.....	9,298	40	9,318
Humboldt	15	.....	1	45,939	638	46,292	12	1	.....	8,836	113	8,893
Lander	12	2	.....	94,503	626	94,849	12	7	.....	160,766	1,189	161,369
Lyon	.....	.....	.....	.....	.....	.....	1	.....	.....	165	2	166
Mineral	7	.....	.....	5,366	178	5,464	5	.....	.....	7,128	181	7,220
Nye	27	12	.....	213,851	4,786	216,498	32	15	.....	204,744	4,462	207,006
Washoe	8	.....	.....	2,146	38	2,167	3	.....	.....	160	2	161
White Pine	5	.....	.....	2,537	20	2,548	1	.....	.....	2,395	21	2,406
	96	14	1	377,262	6,367	380,783	80	23	.....	395,319	6,030	398,376

CHURCHILL COUNTY.

There were 123,991 tons of ore mined in 1915 by 13 producers, against an output of 114,771 tons mined by 19 producers in 1914. The total average value per ton decreased from $10.24 in 1914 to $8.97 in 1915. This value for both years was practically that of gold and silver, as only a small quantity of ore containing copper and lead was shipped. The larger part of the output was of milling grade and yielded gold and silver bullion at cyanidation plants. There was also some gold and silver concentrate containing a little copper produced at one of the plants. This was shipped directly to the

smelters, with 146 tons of crude ore containing copper and lead produced in the county. Although 9,220 tons more ore was mined in 1915 than in 1914, a decrease of $62,115 is shown in the total value, which was due to the decreased production of gold and to the lower price of silver in 1915.

Eagleville district.—A few tons of gold ore, carrying a little silver, was shipped from the Golden Extension property.

Fairview district.—Six deep mine producers reported the output of 65,503 tons of ore. Nearly all of this was the output of the Nevada Hills property. There were 133 tons of concentrate and 52 tons of crude ore shipped directly to the smelters. The total output of the district amounted to $306,152, or an average value per ton of $4.67.

Work at the Nevada Hills property, except by lessees, may be discontinued according to the last annual report of the company,[1] which makes the following statement:

> The mill operated 97 per cent of full time and treated an average of 179 tons per day, including 1,411 tons of tailings that were retreated or 176 tons of crude ore per day. Both records are equal to those of the previous year.
>
> The extraction averaged 81.7 per cent and was 7 per cent lower than 1914. This decrease, when figured against the head value of the ore, amounts to 40 cents per ton, but was planned deliberately, as it allowed a smaller amount of concentrate to be shipped, and a decrease in chemical consumption which effected the saving. * * *
>
> The extensive exploration which has been carried on at the 650-foot, the 800-foot, the 900-foot, and the 1,000-foot levels has shown negative results, and roughly may be said to have prospected the ground to twice the depth of any known ore body. Deep development has, therefore, been stopped and the future production from the mine must, so far as known, come from the shallow workings of the Nevada Hills vein west of the "Big" fault. This remaining ore, occurring in walls of previously worked stopes, is not measurable, but is thought to be insufficient to supply the mill at capacity for the coming year.
>
> The margin [of] profit for 1915, exclusive of interest received from reserve, was slightly under 50 cents per ton; certain months, when taken separately, showed a small loss from operation. For the year, the cost of producing silver was, obviously, but a few cents under the market price.
>
> Toward the close of the year the silver market improved materially, but the price of all supplies had increased proportionately so that, to your property, 56 cents per ounce for silver at present is only equivalent to a price of 50 cents per ounce before the European war.
>
> Operating costs for the past few months are around $3.50 per ton and are believed virtually to have reached a minimum. A further material increase in the ore reserves, as an automatic result of a decrease in operating costs, is, therefore, no longer probable.

Holy Cross district.—There were two producers of silver ore, the Pyramid Fraction yielding the largest quantity.

White Cloud district.—In doing assessment work, some copper ore was mined from one of the properties of the Nevada United Co.

Wonder district.—The principal ore producer in 1915 was the Nevada Wonder mine,[2] which in 1915 produced 58,124 tons of ore containing 1,199,245.83 ounces of silver and 10,278.99 ounces of gold, valued in all at $812,118.88, or an average value per ton of $13.97. Further details of development and costs as given in the company's annual report, follow:

> The principal development now under way in furtherance of the policy of prosecuting exploration below the 1,300-foot level, is the sinking of a three-compartment inclined subshaft from the 1,300-foot level. The subshaft is situated about 1,000 feet south of the Nevada Wonder shaft, at a point from which the downward continuation of the Extension ore shoot may be conveniently sought for. The bottom of the subshaft is now 30 feet below the 1,450-foot level, where a station is being cut,

[1] Nevada Hills Mining Co. Sixth Ann. Rept., for year ending Dec. 31, 1915.
[2] Nevada Wonder Mining Co. Ann. Rept. for year ending Sept. 30, 1915.

and all the necessary preparations have been made to continue sinking to the 1,600-foot level. In the meantime, 200 feet of drifting has been done on the 1,450-foot level through a winze, and this work will be resumed from the subshaft as soon as the 1,450-foot station is completed.

A comparison between the costs of mining operations for the past two years is as follows:

	1913–14	1914–15
Direct cost per ton of ore hoisted	$3.78	$3.33
Indirect cost per ton of ore hoisted	.87	.83
Total operating cost per ton of ore hoisted	4.65	4.16
Total operating cost per ton of ore and waste hoisted	3.01	3.26
Total operating cost per ton of ore and waste broken	2.85	3.13
Transportation of ore to mill per ton of ore hoisted	.05	.035
Subshaft sinking and station cutting per ton of ore hoisted	.55	.18
Subshaft sinking, cost per foot	.....	35.07
Average cost per foot of drifting, crosscutting, raising, and winze-sinking	6.44	7.70

The operating statement shows a decrease of $0.455 in direct costs and $0.04 in indirect costs from the figures of the previous year. This decrease is due principally to the reduction in development operations, but there is also a decrease in the separate costs of superintendence, tramming, hoisting, surveying, assaying, surface and plant, storehouse, and water lines.

The combined costs of the Nevada Wonder Mining Co. and the Churchill Milling Co. and the profits per ton of ore mined and milled, as compared with those of the previous year, are as follows:

	1913–14	1914–15
Mining cost per ton of ore	$4.70	$4.19
Subshaft sinking and station cutting per ton of ore	.55	.18
Enlarging shaft per ton of ore	.04	.....
Milling per ton of ore	3.37	2.81
Marketing products per ton of ore	.28	.27
Total cost per ton	8.94	7.45
Average value per ton of ore	15.52	13.97
Loss in tailings per ton of ore	1.06	.82
Recovery per ton	14.46	13.15
Less total cost per ton	8.94	7.45
Profit per ton of ore mined and milled	5.52	5.70

CLARK COUNTY.

Mine production in Clark County, Nev., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	27	27,810	$92,377	127,233	188,154	4,207,419	11,862,149	$956,822
1915	54	52,797	167,639	160,749	301,327	4,655,985	21,061,182	3,132,290
Increase, 1915	.....	24,987	75,262	33,516	113,173	448,566	9,199,033	2,175,468

Fifty-four mines in the county are credited with a production in 1915 of 52,797 tons of ore, which was 24,987 tons more than was produced by 27 producers in 1914. The total average value per ton increased from $34.41 in 1914 to $59.33 in 1915, and the gold and silver

value per ton in this ore decreased from $5.85 to $4.72. Of the total ore, 21,594 tons were shipped directly to the smelters and produced $32,602 in gold, 16,158 ounces of silver, 300,796 pounds of copper, 1,393,891 pounds of lead, and 12,858,348 pounds of zinc calculated as spelter, valued in all at $1,753,381, or an average value per ton of $81.20. There were 17,385 tons of ore treated by separation process, which produced lead and zinc concentrates. The 16,091 tons of concentrates produced contained $2,892 in gold, 86,426 ounces of silver, 531 pounds of copper, 3,262,094 pounds of lead, and 8,202,834 pounds of zinc calculated as spelter, valued in all at $1,217,272, or at an average value per ton of $75.65. At gold and silver mills, 11,818 tons of ore were treated and produced $132,146 in gold and 58,165 ounces of silver.

Crescent district.—Silver ore taken out during annual assessment work was shipped from the Treasure Trove property.

Eldorado district.—Three producers, the Colorado Nevada, the Techatticup, and one other property produced 6,547 tons of ore, the largest part of which was treated in cyanidation plants. Only 2 tons were shipped directly to the smelter. The total output of ore and bullion containing gold and silver, averaged in value $14.03 per ton.

Gold Butte district.—The Tramp property was reported to have shipped copper oxidized ore in 1915.

Searchlight district.—Thirteen producers in 1915 reported 7,766 tons of ore, containing $103,042 in gold, 3,546 ounces of silver, 20,970 pounds of copper, and 35,562 pounds of lead, valued in all at $110,182, or an average value per ton of $14.19. Of this ore, 5,233 tons were treated at gold and silver mills, yielding bullion, and 113 tons were concentrated, yielding concentrate containing gold, silver, copper, and lead. There were 420 tons shipped directly to the smelters. The Quartette mine, which yielded the largest quantity of ore, was in operation the entire year and its mill was operated during the last eight months. Nearly all of the ore was the output of lessees. Gold bullion and some concentrate were shipped from the Blossom Consolidated. Ore of smelting grade, containing lead and copper with some silver and gold, was shipped from the Duplex property. The Kansas City group, under development by the Big Casino Co., made several tests at the concentrating mill on the property and shipped a small quantity of concentrate, containing principally gold and a little lead and copper. Some ore mined from the Peerless property and treated by the amalgamation process yielded gold and silver bullion.

Sunset district.—It is reported that some gold and silver bullion and some concentrate was shipped from the Lucy Gray property in 1915.

Yellow Pine district.—Altogether 38,391 tons of ore, reported by 35 producers, were mined in the district in 1915, as against 24,537 tons reported by 19 producers in 1914. The output in 1915 contained $833 in gold, 100,146 ounces of silver, 262,609 pounds of copper, 4,620,243 pounds of lead, and 21,061,182 pounds of recoverable zinc, valued in all at $2,926,300, or an average value per ton of $76.22. The largest part of the ore, or 21,119 tons, was of shipping grade and contained 40.29 ounces of gold, 14,140 ounces of silver, 262,600 pounds of copper, 1,359,396 pounds of lead, and 12,858,348 pounds of zinc (spelter). This output of shipping ore is more than double the quantity shipped in 1914. The concentrates shipped contained 86,006

ounces of silver, 3,260,847 pounds of lead, and 8,202,834 pounds of zinc. Most of these concentrates were produced at one wet concentrating plant and the remainder at four other plants equipped with dry concentrators. The largest producer of milling ore was the Yellow Pine property. Other producing properties were the Bullion, Anchor, Boss, Bill Nye, Dividend-Frederickson, Milford & Addison, Alice, Green Monster, Hoosier, Ingomar, Hoodoo, Mobile, Mongolian, Monte Cristo, Potosi, Prairie Flower, St. Anthony, Shenandoah, Christmas, Sultan, Whale, and various properties of the Campbell estate.

The Yellow Pine mine is opened by an incline shaft on an angle of about 35 degrees to a depth of 950 feet. The shaft was sunk 200 feet in 1915. Levels are driven every 100 feet. The fissure deposits have an average strike of N. 30° W., with easterly dip, and the bedded deposits strike nearly due north, with westerly dip. Some of the stopes attain considerable size—100 feet in width and 300 to 400 feet in length. The mill of the Yellowpine Co. is at Goodsprings and is connected with the mine by a narrow-gage railroad. The mill capacity is 100 tons per 24 hours. It was idle about two months in 1915. The ore is fed over a grizzly to a jaw crusher, thence to rolls, impact screens, jigs, and tables. Three products are made—lead concentrate, zinc concentrate, and zinc slimes. These products are separated from an ore containing 10.2 per cent of lead, 31.8 per cent of zinc, and 5.4 ounces of silver. They make a lead concentrate assaying 53.2 per cent of lead, 13.75 per cent of zinc, and 28.1 ounces of silver; a zinc concentrate carrying 4.4 per cent of lead, 33.2 per cent of zinc, and 2.5 ounces of silver; and a zinc slime containing 7.3 per cent of lead, 35.1 per cent of zinc, and 4 ounces of silver per ton. Milling costs during 1915 were $1.46 a ton. Dividends were paid in 1915 amounting to $450,000.

The Sultan mine, one of the large producers, is opened by tunnels and glory hole. At the Anchor a short tunnel is driven and a winze sunk 450 feet below the surface. The Monte Cristo and many smaller properties are opened by surface cuts, and considerable gophering has been done in following the ore. Dry concentrating plants of the Stebbins type have been erected at the Anchor, Bullion, Sultan, and Christmas properties. A Stebbins table was used for a time on the Milford & Addison ores and was then moved to another property. At the Dividend-Frederickson mine a Plumb pneumatic jig was used for a short time, and its use was discontinued for a Sutton table, which is said to have made a satisfactory product. The Potosi ore is calcined at the mine in an oil-fired stack and rotary calcining furnace having a capacity of 30 tons of ore per 24 hours.

DOUGLAS COUNTY.

Five producers reported the output of 146 tons of ore, of which 90 tons were leached in a copper plant, 16 tons containing gold and silver were shipped to the smelters, and 40 tons produced gold and silver bullion at a milling plant. The total value per ton of the ore was $13.68, and the gold and silver value per ton was $7.43. The placer production amounted to $1,378 in gold and 10 ounces of silver.

Gardnerville district.—The reports of two producers gave an output of 16 tons of gold-silver ore, which was shipped directly to the smelter, and 90 tons of copper ore, which was leached in a sulphuric-acid plant,

The principal property operating was the Ruby Hill, at which a 30-ton leaching plant operated by lessees was installed.

Mount Siegel district.—Placers on Buckeye Creek, 20 miles east of Minden, were reported as producing some bullion recovered in doing assessment work.

Silver Glance district.—The Yankee Girl & Mule Shoe property produced a little gold ore taken from the surface and treated in a 5-stamp mill on the property.

ELKO COUNTY.

Mine production in Elko County, Nev., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	45	11,664	$147,177	89,113	273,333	860,826	.....	$266,382
1915	78	19,875	147,468	65,307	413,500	436,848	631,819	351,819
Increase or decrease, 1915	.....	+8,211	+291	−23,806	+140,167	−423,978	+631,819	+85,437

[a] Includes placer production.

The output of ore reported by 75 deep-mine producers was 19,875 tons in 1915, which is 8,211 tons greater than was produced by 38 producers in 1914. The total average value per ton of the ore decreased from $22.56 in 1914 to $17.68 in 1915 and the gold and silver value per ton from $16.57 to $9.07. Most of the ore (15,417 tons) was treated at gold and silver mills and yielded bullion containing $142,481 in gold and 17,975 ounces of silver. There was also a small quantity of gold and silver concentrates produced at one of the mills. The ore shipped was 3,945 tons, containing gold, silver, copper, lead, and zinc valued at $196,506, or an average value per ton of $49.81. Some old tailings and slag were re-treated, and $364 in gold and 8 ounces of silver were reported from placers in 1915.

Aura district.—The Big Four property yielded some ore in 1915, and it is reported that prospects are good for the shipment of a large quantity of ore in 1916.

Contact district.—Five producers reported the production of 36 tons of ore, containing $37 in gold, 278 ounces of silver, and 12,386 pounds of copper, valued in all at $2,346, or an average value per ton of $65.16. The principal producers were the Delano group, Champ Clark, High Ore, and Copper Shield.

Dolly Varden district.—Copper ore containing silver and gold was shipped from the Victoria property in 1915. The ore is hauled by auto truck from the mine to Dolly Varden siding on the Nevada Northern Railway. Some development work was done on the Henry group.

Gold Circle district.—The principal camp in the Gold Circle district is Midas, which is about 47 miles northeast of Golconda, on the Southern Pacific line, and 35 miles from Red House, on the Western Pacific Railway. An auto truck runs regularly between Midas and Golconda, the roads being in fair shape and of easy grade. Machinery

and supplies are hauled from Red House. Nearly all the ore produced in the district by 10 operators—2,946 tons—was treated at gold and silver mills and yielded bullion; and 1 ton of ore, containing gold and silver, was shipped to the smelter. The principal producer was the Elko Prince; it is equipped with a 50-ton cyanide mill, which began to operate November 13. The Elko Prince mine is developed by a crosscut adit about 700 feet long, from which drifts have been driven both north and south a total distance of 1,100 to 1,200 feet on the vein and have given about 350 feet of backs above this level. The Rex mine was the second producer of importance, yielding gold and silver bullion at its custom plant. Other producers were the Esperanza, Hardscrabble, Old Judge, and Midas.

Jarbidge district.—Ten deep-mine producers reported 12,711 tons of ore sold or treated, which contained $101,541 in gold and 5,445 ounces of silver and had an average value per ton of $8.21. All of the ore was milled in plants equipped for amalgamation and cyanidation, and a small quantity of gold and silver concentrate was recovered at one mill. The principal producer was the Bluster group. Considerable ore was also produced from the Alpha, Flaxie, and Bourne properties.

Railroad district.—Ore shipped by 24 producers in the district aggregated 2,210 tons and contained $303 in gold, 31,190 ounces of silver, 359,247 pounds of copper, and 233,659 pounds of lead, valued in all at $89,966, or an average value per ton of $40.71. The principal operations were carried on at the Bunker Hill property, which produced considerable copper-lead ore and copper ore. Other producers were the Emmor, Hecla, Helen M., Lee, Sweepstake, Sylvania, and Copper Bell.

Ruby Mountain Range.—The Michigan mine, leased by the Arthur Zinc Co., made a number of shipments of crude ore and concentrates containing zinc. The property is equipped with a concentration mill containing jigs and tables and has a capacity of 75 tons of ore daily. The principal shipments of oxidized zinc ore were made from the Polar Star property, situated near Warm Creek.

Spruce Mountain district.—Four operators reported the production of 71 tons of ore, containing gold, silver, copper, and lead, valued in all at $3,755, or an average value per ton of $52.89. This output included a small quantity of old smelter slag containing lead and silver. Development work was done at a number of properties, and the ore produced was taken out in the course of assessment and prospect work.

Tecoma district.—The Jackson group produced a small quantity of oxidized lead ore containing silver.

Tuscarora district.—From this district 103 tons of ore containing lead, gold, and silver was shipped directly to the smelter, and 200 tons of old tailings were treated by cyanidation. There were also 29 tons of ore from various properties, from which gold and silver bullion was recovered by amalgamation. Very little development work was done on any of the properties. Reports have been made that the Dexter property will be opened and developed in 1916.

Van Duser district.—The value of the output of gold, silver, and lead from four deep mines and two placers amounted to $569.

ESMERALDA COUNTY.

Mine production in Esmeralda County, Nev., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	50	483,995	$5,226,367	161,921	1,072,408	40,735	$5,460,128
1915	71	470,193	4,689,260	253,180	1,693,450	107,219	5,119,015
Increase or decrease, 1915	.....	−13,802	−537,107	+91,259	+621,042	+66,484	−341,113

[a] Includes placer production.

Altogether 470,193 tons of ore were mined, of which 437,192 tons treated by cyanidation or amalgamation yielded $3,896,724 in gold and 126,002 ounces of silver, or an average value per ton of $9.06. One small lot of ore (94 tons) yielded lead concentrates containing gold and silver. These concentrates, with 32,907 tons of crude ore, were shipped to the smelters. The crude ore contained $792,339 in gold, 127,036 ounces of silver, 1,693,450 pounds of copper, and 71,119 pounds of lead, valued in all at $1,156,443, or an average value per ton of $35.14. The county is credited with a small bullion output from placers, amounting to $85 in gold and 2 ounces of silver.

Basalt district.—In 1915 the Tip Top mine, which is equipped with a cyanidation plant, produced considerable gold ore carrying silver, and the I. X. L. property treated some gold ore in its amalgamation plant.

Copper Flat district.—The Dolly Y. or Anderson property produced a small amount of lead ore containing silver.

Goldfield district.—There has been very little change in the total value of the district output in the last two years.

Metal production of Goldfield district, Nev., 1904–1915.

Year.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
	Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	367,166	$4,705,169	129,830	1,069,021	4,018	$4,919,302
1915	418,935	4,389,385	165,306	1,679,423	.....	4,767,094
Increase or decrease, 1915	+51,769	−315,860	+35,476	+610,402	−4,018	−152,208
Total, 1904–1915	.....	75,700,937	998,748	4,819,203	23,662	77,022,591

Twenty-five producers in 1915 reported an output of ore whose average value per ton was $11.38. The average value of the ore produced in 1914 was $13.40 per ton. The larger part of the output in 1915, or 386,337 tons, was milled at cyanidation plants and yielded 174,248.75 ounces of gold and 47,236 ounces of silver. Ore of shipping grade aggregated 32,598 tons and contained 38,087.74 ounces of gold, 118,070 ounces of silver, and 1,679,423 pounds of copper. The Jumbo Extension property yielded most of this copper, and the Goldfield Consolidated reported a notable quantity. The latter property also produced a large tonnage of concentrate, which was roasted

and treated by cyanidation. Altogether the Goldfield Consolidated mines[1] produced in 1915 a total of 390,054 tons of ore, of which 385,900 tons, having an average value of $10.37 per ton, were milled, and 4,154 tons, having an average value of $23.53 per ton, were shipped. The gross value of the ore produced was $4,101,247.16. The following table is taken from the annual report of the company:

Production of Goldfield Consolidated Mines Co., 1915.

	Production (short tons).	Total value (and deductions).	Average per ton.	Per cent of total value.
Tons milled	385,900	$4,003,483.70	$10.37	.....
Loss in tailing	.....	382,214.46	.99	.....
Value recovered	.....	3,621,269.24	9.38	90.45
Tons shipped	4,154	97,763.46	23.53	.....
Smelter discount	.....	17,511.41	4.22	.....
Smelter settlements	.....	80,252.05	19.31	81.30
Total production	390,054	3,701,521.29	9.49	90.25
Cost of ore purchased and amount paid lessees	.....	185,687.70	.48	.....
Values realized	.....	3,515,833.59	9.01	85.73
Net costs	.....	1,957,525.28	5.02	.....
Net realization from operation	.....	1,558,308.31	3.99	37.99

Shaft.	Milling ore.			Shipping ore.		
	Short tons.	Average value.	Total value.	Short tons.	Average value.	Total value.
Mohawk	193,802	$9.48	$1,836,819.19	.....	.....	.....
Combination	39,590	13.27	525,320.68	.....	.....	.....
Jumbo-Clermont	37,703	10.69	402,954.87	3,500	$26.70	$93,434.90
Laguna	60,185	10.06	605,528.89	44	15.08	663.33
Jumbo No. 2	729	2.81	2,049.91	.....	.....	.....
Dumps	43,339	5.99	259,442.14	.....	.....	.....
Leasers	10,141	36.21	367,234.40	610	6.01	3,665.23
Ore purchased	411	10.05	4,133.62	.....	.....	.....
	385,900	10.37	4,003,483.70	4,154	23.53	97,763.46

Total costs per ton, including construction, were $1.03 lower than for the previous year, and operating costs, excluding construction, were 79 cents per ton lower than for the previous year. * * *

Development work has been performed within the year of 34,603 feet at a cost per foot of $5.73.

With the dividend paid in 1915, this company has disbursed a total of $28,999,832.

In 1915 the Jumbo Extension property[2] produced 22,562 tons of crude ore containing 30,480 ounces of gold, 99,459 ounces of silver, and 1,259,388 pounds of copper. Most of the ore mined in 1915 was from the Velvet claim,[3] recently purchased. The old part of the mine produced in the fiscal year 9,049 wet tons of shipping ore, averaging $74.14 per ton in gold, silver, and copper, and 2,545.7 wet tons of milling ore, averaging $11.14 per ton.

[1] Goldfield Consolidated Mines Co. Ninth Ann. Rept., for year ending Dec. 31, 1915.
[2] Min. and Sci. Press, Feb. 12, 1916, p. 253.
[3] Jumbo Extension Mining Co. Ann. Rept. for year ending June 30, 1915.

The Florence Goldfield mine[1] in 1915 yielded 3,194.15 dry tons of ore, which had a gross value of $55,638.58, or an average value per ton of $17.42. The following is an extract from the company's report:

Practically the entire tonnage shipped during the year was mined from the vein exposed November, 1914. The ore body proved to be very irregular, both in size and in its metal contents. All of the stope had to be timbered with square sets in order to keep the wall rock from caving and mixing with the broken ore, both walls being composed of very soft decomposed dacite. This ore body ceased to produce pay ore in September, 1915, and since then no ore has been shipped from the mine. There still remains about 1,000 tons of low-grade ore, assaying from $4 to $7 per ton. * * *

A lease on the surface dumps of the property was granted on October 14, 1915, for a period not to exceed two years. * * * A company known as the Nevada Metals Extraction Co. was organized to erect a mill on the site of the old cyanide mill to treat the low-grade ore in the surface dumps by the flotation process. The construction of this mill was started in December, 1915. * * * The crushing department of the mill will consist of a gyratory crusher, a set of rolls, and a ball mill, giving a crushing capacity of at least 150 tons of ore per day. The flotation department will consist of 2 Janney emulsifiers and 10 Janney flotation machines. An Oliver vacuum filter will be installed for dewatering concentrates, and a 30-foot Dorr thickener for dewatering the discharge pulp. Other necessary elevating, conveying, classifying, and pumping machinery will be installed in a substantial frame and sheet-iron mill building.

The Atlanta Mines, Belmont Goldfield, Combination Fraction, Diamondfield Daisy, and Great Bend were also important producers.

Gold Mountain district.—The 1915 output was 341 tons of ore, containing $6,683 in gold, 4,882 ounces of silver, and a little lead and copper, valued in all at $9,385, or an average value per ton of $27.52. The larger part of the ore was treated at milling plants. Some of it was hauled to Tonopah for treatment in the West End mill. The principal producers were the Hasbrouck, Chief, and Divide.

Hornsilver district.—Most of the 1,705 tons of gold and silver ore produced in the district was treated at a custom cyanide mill near Tonopah. Only 33 tons containing gold, silver, and copper, were shipped to the smelters. The principal producer was the Orleans group, and smaller quantities came from the Galena Gold, Atlas, Little Carrie, and Silver King properties.

Lida district.—All the ore produced in 1915, 24 tons, was shipped and contained gold, silver, and copper. Work was done on the Rider, President, and Copper Blossom group.

Lone Mountain district.—The General Thomas, Great Seal, Sunset, Tetrahedrite, and Quincy properties were the principal contributors to the district output, which was 131 tons of smelting ore, containing gold, silver, lead, and a little copper, valued at $5,981, or an average value per ton of $45.66.

Montezuma district.—A small quantity of lead ore, carrying silver, was shipped in 1915 from one property in the district.

Silver Peak district.—With the closing of the Pittsburg-Silverpeak property in October, activity in the district ended. There were 7 producers in 1915, reporting the production of 44,935 tons of ore. The bulk of the output was that of the Pittsburg property and was treated in its 120-stamp mill amalgamation and cyanidation plant. This mill was being dismantled late in December, and it is reported that the mine is to be abandoned.

[1] Florence Goldfield Mining Co. Ann. Rept. for year ending Dec. 31, 1915.

EUREKA COUNTY.

Mine production in Eureka County, Nev., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	45	76,326	$306,852	164,202	6,800	391,690	13,439	$414,521
1915	46	109,320	334,047	186,583	15,813	1,299,085	61,053	500,040
Increase, 1915		32,994	27,195	22,381	9,013	907,395	47,614	85,519

[a] Includes placer production.

Ore produced in 1915 by 46 operators aggregated 109,320 tons, which is 32,994 tons more than was produced by 33 operators in 1914. The total average value per ton decreased from $5.32 in 1914 to $4.49 in 1915, and the gold and silver value in this ore from $5.10 to $3.84 per ton. Of the ore, 103,528 tons were treated at gold and silver mills, yielding bullion containing $289,943 in gold and 106,081 ounces of silver, having an average total value of $3.32 per ton. There were 3,000 tons of ore concentrated, yielding concentrates containing gold, silver, copper, and lead, and 2,792 tons were shipped directly to smelters, containing $23,084 in gold, 63,662 ounces of silver, 13,913 pounds of copper, 1,239,085 pounds of lead, and 61,053 pounds of zinc, valued in all at $123,604, or an average value per ton of $44.27. Placer bullion reported from 8 sources amounted to $9,298 in gold and 40 ounces of silver.

Cortez district.—The concentration mill of the Cortez Milling & Reduction Co. was destroyed by fire in August. Some ore was treated previous to the fire.

Eureka district.—Twenty-five producers shipped 1,135 tons of ore, containing $22,578 in gold, 34,308 ounces of silver, 5,653 pounds of copper, 393,526 pounds of lead, valued in all at $59,457, or an average value per ton of $52.39. The largest shipments came from the Richmond-Eureka, California & Silver King, Silver Lick, and Windfall properties. Most of the mines in the district were operated by lessees.

Lynn district.—Eight placer producers reported an output amounting to $9,298 in gold and 40 ounces of silver, as against $8,486 in gold and 25 ounces of silver in 1914. The placers from which most of the 1915 output came were the Morning Star, Hilltop, Compromise No. 10, Golder Doll, Jingo, and Mephisto. There were interesting developments at one of the quartz mines, but no production. It is expected that one or two deep mines will be producers in 1916.

Mill Canyon (Buckskin) district.—The Buckhorn property was operated and ore treated in the cyanidation plant, yielding gold and silver bullion.

Mineral Hill district.—All the ore shipped from the district, aggregating 1,547 tons, was smelted and produced $436 in gold, 25,071 ounces of silver, 7,445 pounds of copper, 821,009 pounds of lead, and 61,053 pounds of zinc, valued in all at $60,608, or an average value per ton of $39.18. Six producers reported this output, the

principal ones being the Union and the Mineral Hill Consolidated properties. It is reported [1] that there is approximately 10,000 tons of ore on the dumps of the Mineral Hill Consolidated that will average about 30 ounces of silver, and that the water supply in the district is adequate for a 50-ton concentrator.

Safford district.—A small output of lead ore, containing silver and a little copper, was shipped from the Zenoli property.

HUMBOLDT COUNTY.

Mine production in Humboldt County, Nev., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	94	30,569	$563,485	691,778	32,952	32,495	$951,688
1915	109	56,683	809,343	740,560	51,362	101,088	1,198,546
Increase, 1915		26,114	245,858	48,782	18,410	68,593	246,858

[a] Includes placer production.

The output of ore in the county in 1915 was reported by 96 producers, against 78 producers in 1914. The total average value per ton decreased from $29.62 in 1914 to $20.99 in 1915. This value was practically all for gold and silver. Milling plants using principally the cyanidation process treated 53,113 tons of ore, which yielded $640,442 in gold and 563,761 ounces of silver, having an average value per ton of $17.44. Some gold and silver concentrate was also produced at the milling plants and with a small production of lead concentrate was shipped to smelters. Ore of shipping grade aggregated 3,488 tons and contained $24,224 in gold, 152,147 ounces of silver, 51,239 pounds of copper, and 93,616 pounds of lead, valued in all at $114,730, or an average value per ton of $32.89. There was also a small output from old tailings and slag. The placer output reported from 13 sources amounted to $8,836 in gold and 113 ounces of silver, as against $45,939 in gold and 638 ounces of silver in 1914.

Amos district.—The D. & C. mine was operated by lessees, who produced ore containing gold and silver. About 350 tons were treated in an amalgamation plant, and the remainder, or 18 tons, was treated by cyanidation.

Antelope district.—At the Antelope Springs property the company was busy completing a 25-ton concentrating plant, which was expected to be in operation early in 1916. Some ore was shipped from this property. The Haystack property produced gold ore, which was treated in its 5-stamp amalgamation mill. Copper ore was shipped from the Majauba Hills, and lead-sulphide ore from the Nevada Superior property.

Dun Glen district.—Small shipments of bullion continue to be recovered from the ores mined from various properties in the district. Some ore of shipping grade, containing lead and silver, was

[1] The Mineral Hill mining district, Nev.; Min. and Eng. World, June 19, 1915, p. 1117.

produced from the Sheba mine, and the Diamond C and Black Hole properties yielded a small quantity of ore, which was treated in an amalgamation mill. The Sheba is opened by an adit 1,315 feet long, near the end of which a new silver-lead vein was encountered in 1915, which caused the company to reconstruct its milling plant and to add 15 stamps to its concentration equipment.

Gold Run district.—There were 12 producers reporting 763 tons of ore, containing $2,587 in gold, 2,718 ounces of silver, 38,416 pounds of copper, and 32,584 pounds of lead, valued in all at $12,219, or an average value per ton of $16.02. Of the ore, 389 tons yielded gold and silver bullion at milling plants, and 374 tons, containing lead and copper, were shipped directly to the smelter. The principal shippers were the Caroline, Copper Queen, Gold Ledge, Gold Crown, and Silver Shield.

Imlay district.—In 1915 there were 5 properties producing 68 tons of smelting ore, containing gold, silver, and lead.

National district.—The 10-stamp ball amalgamation and concentration mill of the National Co. was in operation the entire year. The Buckskin property yielded a few tons of gold and silver ore, which was shipped to the smelter.

Paradise Valley district.—The ore produced came from one property and contained gold and silver.

Rochester district.—There were 20 deep mines and 5 placer producers reporting the production of $105,407 in gold, 663,791 ounces of silver, 22,716 pounds of lead, and a little copper, valued in all at $443,091. The larger part of the ore, 24,145 tons, was milled, yielding gold and silver bullion, and at one plant some concentrate was produced. There were shipped from the district 2,520 tons of ore, containing 551.32 ounces of gold, 121,784 ounces of silver, and some lead and copper. The Rochester Mines Co. was the heaviest producer of milling ore and also shipped some ore to the smelter. According to its report for the fiscal year[1] the ore from this company's mine was produced almost entirely by lessees, but the practice was largely discontinued during 1915 and completely ended by August 15, on account of their ruinous methods of mining. On March 28, 1915, the new mill began operations. There was considerable delay in the first four months, owing to the inability of the lessees at the mine to supply sufficient ore to operate the mill at capacity. During the later part of the year the delays were due to snowstorms and to a fire that destroyed the locomotives used in transporting ore from the mine to the mill. The average cost of mining the ore for a period of 12½ months was $3.3459 per ton; milling, $2.6929; marketing bullion, $0.2688; transportation, $0.5214. The mill is reported[2] to have treated from April 1 to December 31 23,090 tons of ore, yielding 3,131 ounces of gold and 545,954 ounces of silver, valued at $332,818. The mill is equipped entirely for the treatment of the ore by cyanidation, and is rated[3] as having a capacity of 120 tons of ore daily. It is stated that the lessees had naturally endeavored to extract the greatest quantity of high-grade ore at the least possible expense, without any regard to the future working of the property. Power for the mine is furnished

[1] Rochester Mines Co. Ann. Rept. for year ending May 15, 1916.
[2] Min. and Sci. Press, Jan. 29, 1916, p. 183.
[3] Min. and Sci. Press, Aug. 28, 1915, pp. 317-320.

by the Nevada Valleys Power Co., from the Lahontan dam, a Government irrigation project 85 miles distant. This power is furnished at $8 per horsepower per month. It is estimated that the Rochester Mines Co. has about 10,000 tons of ore broken in the stopes.

Milling ore was also mined from the Packard mine and treated in its 100-ton cyanide plant, which was completed December 3, 1915. The ore from the Packard mine is described[1] as a highly altered sericitized rhyolite, varying from a soft and friable talcose or schistose rock to an extremely tough silicified variety. The rhyolite is traversed by scattered stringers of quartz. Cerargyrite is the valuable constituent of the ore. Sulphides occur sparingly, and sulphantimonates or arsenates are extremely rare. The ratio of gold to silver is about 1 to 300. In places small quartz veinlets carry a much higher proportion of gold, giving a string of colors when panned. Preliminary tests showed the ore to be easily amenable to cyanidation. Briefly, the process includes crushing dry in rolls, grinding in tube mills, agitation, and modified counter-current decantation followed by filtration.

The Lincoln Hill property has a 2-stamp amalgamation and concentration mill, which treats 8 tons of ore in 24 hours. Ore of shipping grade was produced principally by lessees from the Crown Point and other properties.

Rosebud district.—Lessees operating on various properties produced a small quantity of ore, which was shipped to smelters.

Seven Troughs district.—Of the 8,038 tons of ore mined in the district 7,936 tons were milled, producing gold and silver bullion at cyanidation plants and some concentrate, which was shipped to smelter. There were also 42 tons of ore, containing gold and silver, shipped to the smelter. The total output, including a little bullion from surface mines, was valued at $476,535. The total ore produced had an average value of $59.24 per ton. The Seven Troughs Coalition, operating its own mill, the Delaware, using the Darby plant, and the Fairview mines were the principal producers. A small output of ore from the Signal Peak property was treated at a local mill.

Sierra district.—The Superlative property, 20 miles south of Winnemucca, produced some gold and silver bullion and ore of shipping grade containing lead and gold with a little silver and copper. The two-stamp concentration and cyanidation mill on the property was idle.

Trinity district.—Two mines yielded milling ore containing gold and silver. The Evening Star was the principal producer.

Unionville district.—The largest part of the ore output was of milling grade mined from the Star Peak property. A small output was produced from the Rusty Pick claim. Some bullion and concentrate was recovered, and 45 tons of ore, containing gold and silver, was shipped to the smelter.

Warm Springs district.—Ore from the Ashdown property was treated in a milling plant in the district and yielded gold and silver bullion.

Willard district.—The Honey Bee and Sheepherder properties produced gold and silver ore, all of which was shipped to the smelters.

[1] Thomson, H. G., Min. and Sci. Press, Sept. 9, 1916, p. 377.

A small boom was occasioned by the discovery of free gold in a prominent outcrop, but nothing was found warranting a permanent camp, so the tent city disappeared as quickly as it had been erected.

Winnemucca Mountain district.—Ten operators reported the production of 138 tons of ore, which contained gold, silver, copper, and lead, valued at $4,264, having an average value per ton of $30.90. Placer gold reported from one source amounted to $624 in gold and 5 ounces of silver. The Black Beauty and Neshobe were the principal producers.

LANDER COUNTY.

In Lander County 23 producers reported the output of 17,700 tons of ore, 11,227 tons more than was reported by 15 producers in 1914. Owing to the larger tonnage of milling ore, the total average value of the ore decreased from $20.05 in 1914 to $5.35 in 1915. The larger part of this value was represented by the gold and silver content. At gold and silver mills 1,030 tons of ore yielded $17,545 in gold and 50,214 ounces of silver, an average value of $41.75 per ton. The ore of shipping grade amounted to 670 tons, containing $6,444 in gold, 79,727 ounces of silver, 6,760 pounds of copper, and 76,686 pounds of lead, valued in all at $51,653, or an average value of $77.09 per ton. A record amount of placer gold was produced by 19 operators, $160,766 in gold and 1,189 ounces of silver, against a production in 1914 by 14 operators of $94,503 in gold and 626 ounces of silver.

Battle Mountain district.—Six deep mines and 17 placers yielded $162,444 in gold, 2,532 ounces of silver, 1,920 pounds of copper, and 20,060 pounds of lead, having a total value of $165,008. The total output of ore was 135 tons, of which 75 tons containing copper and lead were shipped and 60 tons were milled. The ore had an average value per ton of $28.22. The placer output, amounting to $160,596 in gold and 1,187 ounces of silver, came principally from the Dahl placers, in Copper Canyon, where work was carried on in cement gravel by drift mining and sluicing. Considerable amounts were also produced by the Hawkeye, Marietta & Piute, Oversight, Pactolus, Comet, Bannock, and Blue Jacket placers. In Lewis Canyon an oil flotation plant to treat ores from the Starr-Grove group was under construction.

Cortez district.—The Garrison group produced lead ore of shipping grade and some siliceous ore carrying a little copper and lead. The output from the Cortez property came from old mill tailings, re-treated by cyanidation.

Hilltop district.—The Kimberly Consolidated and Gray Eagle claims yielded ore containing gold and silver.

Kingston district.—In 1915 some old tailings were treated in the cyanidation mill of the Kingston property.

Lander district.—Four deep mines yielded 128 tons of ore, containing $293 in gold and 31,876 pounds of silver and having an average value per ton of $128.54. The Aztec property was the main producer of silver ore, and its ore contained a little gold.

Reese River (Austin) district.—Some of the old tailings of the Austin-Manhattan property were treated in the Kingman 30-ton cyanide plant, and a small quantity of gold and silver ore was shipped from the property.

LINCOLN COUNTY.

Mine production in Lincoln County, Nev., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	20	91,332	$57,366	408,286	660,589	5,985,679	1,104,644	$660,785
1915	19	130,152	40,477	457,825	297,183	7,695,155	2,579,745	1,006,161
Increase or decrease, 1915		+38,820	−16,889	+49,539	−363,406	+1,709,476	+1,475,101	+345,376

The ore reported in 1915 was produced by 19 operators, against 20 operators in 1914. The average value per ton increased from $7.23 to $7.73. The gold and silver value, however, decreased from $3.10 to $2.09 per ton. The greater part of the ore, 125,645 tons, was of shipping grade and contained $34,788 in gold, 419,669 ounces of silver, 297,183 pounds of copper, 7,681,117 pounds of lead, and 2,579,745 pounds of zinc (calculated as spelter), valued in all at $980,468, or an average value per ton of $7.80. Ore treated at gold and silver mills aggregated 2,468 tons and yielded bullion and some gold and silver concentrate. At one concentrating plant a small quantity of lead concentrate was produced. No placer gold was reported in 1915.

Eagle Valley district.—The Winner property, at Fay, was operated a few months, and a small quantity of gold ore was shipped from it to the smelter.

Groom district.—Sulphide lead ore, containing silver and a little copper, was shipped from the Groom mine. There is a hand jig on the property by which much of the ore is sorted before shipment. The property has been leased above the 100-foot level, and most of the product in 1915 came from that part of it. There are two shafts 180 feet and 170 feet deep.

Hiko district.—Some old dump material was jigged and a little concentrate containing gold and silver shipped.

Pioche district.—The ore output of 16 deep-mine producers aggregated 129,957 tons, containing $39,159 in gold, 454,382 ounces of silver, 295,703 pounds of copper, 7,523,857 pounds of lead, and 2,579,745 pounds of zinc, valued in all at $994,788, or an average value per ton of $7.65. The larger part of the output was oxidized iron ore which had a fluxing value in addition to the other metal contents. This value, however, was not included in these totals. The largest producer of ore of this kind was the Prince Consolidated. Notable shipments of ore were made from the Consolidated Nevada-Utah and Amalgamated Pioche properties. The output of the Consolidated California-Nevada at Bristol is included in the district output. The 50-ton concentration and cyanidation mill on the Yuba property was started the middle of October. Two concentration plants are planned, one for the Consolidated Nevada and the other for the Prince Consolidated.

The Prince mines produced 119,003 tons of iron-manganese ore, including some tailing from old dumps, which sold for $312,440.91.

The Prince Consolidated announced the early erection of a concentrator to treat the tailing dumps at Bullionville.[1] The lode claims of the company, 23 in number, are southwest of Pioche. A hoisting plant capable of handling 500 tons of ore daily serves the present needs. The mine is opened to a depth of 500 feet and has several miles of drifts on some large bodies of iron-manganese ore, assaying 3 to 4 per cent of lead, 3 ounces of silver, some gold, 34 per cent of iron, 13 per cent of manganese, 3 per cent of lime, and 14 per cent of silica. About 12,000 tons of ore of this kind were shipped monthly to the Salt Lake smelters. No work has been done below the water or sixth level, except by diamond drills, which have penetrated sulphide ore containing lead, silver, and zinc. In order to transport its ores quickly and at a small cost, the company built a broad-gage line 9 miles long, from the Pioche terminus of a branch of the Salt Lake & Los Angeles Railway to the Prince mine. At Dry Valley and Bullionville the company owns 120,000 tons of old tailings assaying from 6 to 8 per cent of lead and 11 ounces of silver and $1.40 in gold per ton. It is to work these tailings that the proposed concentrator using the flotation process is to be erected. The mill was to be in operation about August 15, 1916.

LYON COUNTY.

The output of 16,770 tons of ore, reported by 41 producers in 1915, is 95,946 tons less than was reported by 47 producers in 1914. The total average value per ton increased from $9.20 in 1914 to $12.91 in 1915, and the value of the gold and silver in the ore from 61 cents to $5.60 per ton. There were 7,221 tons of ore and 4,813 tons of old tailings treated at amalgamation and cyanidation plants, yielding $84,996 in gold and 15,679 ounces of silver and having an average value per ton of $8.42. At concentration mills 1,000 tons of ore yielding copper concentrates were treated, and 3,736 tons of ore were shipped to smelters, containing $353 in gold, 996 ounces of silver, and 657,950 pounds of copper, valued in all at $115,999, or an average value per ton of $31.05. A small quantity of placer bullion amounting to $165 in gold and 2 ounces of silver was produced.

Silver City district.—The output of 29 operators on various mining properties in the district aggregated 12,034 tons and contained $84,996 in gold and 15,679 ounces of silver, or an average recovery value of $7.72 per ton. The entire output of the camp and some old tailings were treated in milling plants, principally by amalgamation. The Metals Recovery Co. produced some gold and silver bullion from old Comstock mill tailings treated in its mill between February and May. Lessees operated the cyanidation and amalgamation plant of the Silver City Gold & Silver Mining Co.

Yerington district.—Twelve producers reported the output of 4,736 tons of ore, containing $354 in gold, 1,132 ounces of silver, and 700,874 pounds of copper, valued in all at $123,581, or an average value per ton of $26.09. The Blue Stone property was the principal producer of copper ore, followed by the Nevada Douglas, Empire Nevada, Montana Yerington, Yerington Consolidated, New Yerington, and Gallagher properties.

[1] Prince Consolidated Mining & Smelting Co. Ann. Rept. for year ending Dec. 31, 1915.

According to the annual report of the company owning the Mason Valley property [1] the mines are being kept in good condition and ready to resume operations. Work at the smelter and mines was discontinued in October, 1914. No production was recorded in 1915.

The Nevada-Douglas Co. shipped copper ore from its properties in 1915 and hastened the completion of its milling plant. The following description is taken from the company's annual report: [2]

Construction work on the mill was practically completed about the first of November, * * *.

The mill is primarily designed to treat the ore peculiar to the mining region bordering on Mason Valley, although the processes developed could be adapted to other general conditions. The ore available at the company properties consists of sulphide, oxidized, and mixed ores. The gangue is either garnetiferous, siliceous, or calcareous, depending on the mines from which the ore is derived. Copper is the principal metal value, very little gold or silver being present in the ores.

The ore is delivered from the mines to coarse ore bins, which deliver the material to a 24-inch conveyor. The conveyor transfers the ore to a grizzly, the oversize passing to a Blake crusher. The undersize, together with the broken material from the Blake, is elevated to an intermediate crusher, which feeds to a set of rolls. The material is then discharged to a screen, from which the fines pass directly to either an oxidized or sulphide fines ore bin, depending on the constituents of the ore, and the oversize to a set of fine rolls. The discharge from the rolls is screened, the undersize passing to storage bins and the oversize back to the rolls. The final product of the grinding is expected to pass through a 15-mesh screen.

The sampling is performed by means of a chain-bucket sampler, a Vezin sampler, and the usual sampling arrangements.

The material from the sulphide ore fines bin is conveyed to the chemical building. It may be here diverted either to a bin which feeds a nitric acid digestor, or to a cross conveyor feeding two 17-foot Wedge muffle roasters. The nitric acid portion of the plant is as yet not in regular operation and may for the time be neglected. The Wedge furnaces are now treating between 70 and 80 tons of ore per day, discharging a sulphatized material, containing about 40 per cent of the copper values in the form of water-soluble sulphates.

By means of an elevator the sulphatized ore is discharged to a launder through which it is washed by a stream of water to a set of absorption tanks. In this apparatus the mixture is maintained in the path of hot fumes of sulphuric and sulphurous acid derived from roasting sulphates and sulphides. The heat and agitation of the mixture in the presence of the fumes cause a rapid solution of the oxidized copper values.

The warm solutions pass from the absorption tanks to the precipitation boxes, where the copper for the present is to be recovered as precipitates. Later the copper is to be precipitated electrolytically by methods devised by the company's metallurgists. In any case the solutions from the precipitation of the copper, heavily charged with iron, are passed to an evaporator.

The evaporator, consisting of a network of slats, concentrates the sulphate solutions to crystallization. The crystals separate in a large tank beneath the evaporator and are then transferred by means of a drag conveyor to a set of dryers.

The dryers remove the water of crystallization and transform the mushy crystals to a vitreous mass, which is ground and broken by rotating shoes in the dryers. This material is gradually worked through the dryers and finally falls to an elevator, which discharges the material to the roaster.

Disintegration of the iron sulphate in the roaster results in the production of a very fine red pigment and the development of sulphuric acid fumes. The pigment will become a valuable by-product of the ore treatment after the application of the finishing process, which the company is now developing.

The acid fumes are forced into the absorption tanks previously referred to and enter again on a cycle of active attack on the copper compound present in the ore or calcine submitted to their action.

In addition to the charge of sulphatized material, a continuous flow of oxidized fines, at the rate of 250 tons per day, is caused to drop into the absorption tanks. This, together with the furnace product, undergoes the treatment with the acid fumes in the manner previously described.

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[1] Mason Valley Mines Co. Ann. Rept. for year ending Dec. 31, 1915.
[2] Nevada Douglas Consolidated Copper Co. Ann. Rept. for year ending Dec. 31, 1915.

The leached material from the absorption tanks is discharged by gravity to a set of 30-foot Trent replacement tanks, and the clarified solution allowed to flow to stock tanks, from which it is later pumped to the precipitation launders. * * *

In a very few months the company's mill and leaching plant will be in full commission and equipped to treat not only its own ores but also the custom ores of the district seeking a market. * * *

Our first carload of copper precipitates, familiarly known as cement copper, amounting to about 40 tons, is ready for shipment.

MINERAL COUNTY.

Ninety-three producers reported the production of 191,256 tons of ore, or 115,099 tons more than was reported by 99 producers in 1914. The total average value per ton decreased from $6.79 in 1914 to $5.12 in 1915, and the value of the gold and silver in the ore from $6.33 to $4.67. The larger part of the ore was treated at gold and silver mills, yielding $681,993 in gold and 228,638 ounces of silver. This bullion included the recoveries made from 31,148 tons of old tailings re-treated by cyanidation. There were 4,677 tons of crude ore shipped to smelters, containing $63,350 in gold, 63,412 ounces of silver, 433,584 pounds of copper, and 221,047 pounds of lead, valued in all at $181,766 pounds of copper, and 221,047 pounds of lead, valued in all at $181,766, or an average value per ton of $38.86. The output reported from 5 placers amounted to $7,128 in gold and 181 ounces of silver, against $5,366 in gold and 178 ounces of silver in 1914.

Aurora district.—The output of 141,421 tons of ore reported by 3 producers yielded gold and silver bullion which, including that from 3,000 tons of old tailings, had a total value of $528,097. The principal part of the ore output was from the Aurora Consolidated mine, and the tailings of early operations were treated in the Baldwin cyanide plant. The Aurora mill [1] was closed for two months while the Merrill slime filter presses were being installed. Since the beginning of operations in July, 1915, 180,529 tons of ore have yielded an average of $3.546 per ton in bullion, with a loss of 0.587 cent in the tailings. The cost of mining in the last 12 months was $1.391 per ton and that of milling was $1.32. It is expected to reduce the average cost of mining and milling in 1916.

Belleville or Columbus district.—The greater part of the output of the district, consisting of gold and silver bullion, was from the Belleville tailings. Some ore from the Badger property, on Black Mountain, was shipped to the smelter.

Hawthorne district.—The 405 tons of ore reported by 9 deep-mine operators contained gold, silver, copper, and lead, which, with a small placer production from two sources, amounted to $14,044. The larger part of the ore, or 305 tons, was treated at gold and silver mills; 100 tons, containing the copper and lead, were shipped to the smelter. Ore from the New York claim was milled, and a quantity of lead oxidized ore carrying silver was shipped from the Lucky Boy property. At Pamlico the placers were worked by drift mining. The gravel was hoisted by means of a gasoline engine from bedrock said to be 126 feet deep on one of the leased blocks of ground. The gravel was sluiced and said to carry $1.50 to $4 per yard in gold and silver.

Holy Cross district.—The Billy Boy property, of the Minerva Mining Co., produced a small quantity of copper ore containing a little silver.

[1] Goldfield Consolidated Mines Co. Ninth Ann. Rept., for year ending Dec. 31, 1915.

Klondike district.—A small quantity of ore was treated in an arrastre on the Umpah property, and a small lot of lead ore was shipped from another property in the district.

Penrod district.—The Lakeview property yielded some gold and silver ore and a small quantity of copper ore, which was shipped to the smelter.

Pine Grove district.—At the Rockland property of the Pittsburg-Dolores Co. the cyanide mill was operated part of the year, beginning in June. The ores mined and treated contained gold and silver, which was recovered by the cyanide process. A small quantity of gold and silver ore was treated at the mill of the Wheeler Gold Mines Co. and yielded bullion. An interesting account of the tests made at the Pittsburg-Dolores mill was recently published.[1]

Rand district.—The Lone Star, Golden Pen, and Last Hope properties were the principal producers of shipping ore. Altogether the total output amounted to 212 tons of ore, containing gold, silver, and a little copper and having an average value per ton of $146.17.

Rawhide district.—The output of 15 deep mines amounted to 6,973 tons of ore, containing $82,042 in gold and 78,512 ounces of silver, valued in all at $121,848, or an average value per ton of $17.47. The placer bullion recovered from surface mines amounted to $5,678 in gold and 166 ounces of silver. Most of the ore came from the property of the Nevada New mines, on which the 10-stamp mill and cyanide plant was operated continuously during 1915. Considerable quantities were also mined from the Black Eagle, Bullskin, and Royal Coachman.

Santa Fe district.—Twenty deep mines produced 2,726 tons of ore, containing $2,987 in gold, 6,802 ounces of silver, 384,258 pounds of copper, and 3,468 pounds of lead, valued in all at $73,844, or an average value per ton of $27.09. All this ore was shipped. The principal producers were the Never Sweat, Champion, Mayflower, Calvada Copper, and New York. Smaller outputs were made from the Red Top, Vacation, and Shipper Copper mines.

Silver Star district.—Twenty-one producers reported 2,016 tons of ore that contained $31,597 in gold, 14,843 ounces of silver, 41,138 pounds of copper, and 181,031 pounds of lead, valued in all at $54,829, or an average value per ton of $27.20. The larger part of the ore, or 1,254 tons, containing lead and copper, was shipped, and 762 tons yielded gold and silver bullion and a small quantity of concentrate. The principal gold producer was the Douglas property, on which is situated a 5-stamp amalgamation mill, where the bulk of the ore was treated. Some of the ore was shipped to the custom mill at Millers. The Moho was a producer of lead oxidized ore, containing silver, and some ore of milling grade, which was shipped to a custom cyanide plant. The Sunshine mine was operated, and ore yielding gold and silver bullion was treated in a 5-stamp mill.

Sulphide district.—From the Tango property a small quantity of gold ore was shipped to the smelter.

Washington district.—A property on East Walker River near Wichman was operated a short time and produced a few tons of copper ore containing a little gold and silver.

[1] Cyaniding by continuous decantation at Two Nevada Silver Mills: Met. and Chem. Eng. Jour., Apr. 15, 1916, p. 435.

NYE COUNTY.

Mine production in Nye County, Nev., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	123	629,970	$3,377,262	11,424,769	3,262	13,290	$9,696,111
1915	119	630,987	2,956,380	10,220,018	2,345	201,982	8,147,832
Increase or decrease, 1915		+1,017	−420,882	−1,204,751	−917	+188,692	−1,548,279

[a] Includes placer production.

The output of 630,987 tons of ore was reported in 1915 by 72 operators of deep mines. This is 1,017 tons more than was reported by 84 operators in 1914. The total average value per ton decreased from $15.05 in 1914 to $12.58 in 1915. The value for 1915 is practically that of the gold and silver. Nearly all the ore, or 629,317 tons, was treated at gold and silver mills, yielding bullion containing $2,653,531 in gold and 9,618,831 ounces of silver, having an average value per ton of $11.97. In addition to the bullion produced, 1,419 tons of concentrates were shipped to the smelters, containing $77,231 in gold and 552,630 ounces of silver and having an average value per ton of $251.87. The ore of shipping grade amounted to 699 tons and contained $19,277 in gold, 27,584 ounces of silver, 2,345 pounds of copper, and 201,982 pounds of lead, valued in all at $43,165, or an average value per ton of $61.75. The placer gold reported from 47 operators amounted to $204,744 in gold and 4,462 ounces of silver, against a production in 1914 of $213,851 in gold and 4,786 ounces of silver.

Bellehellen district.—The Clifford property was worked the entire year, and its milling plant from May until October. The ore contained hornsilver, which is easily amalgamated, and was treated in a 2-stamp Tetrault mill.

Belmont district.—There was some activity in the district on the Monitor-Belmont property, which is equipped with a 10-stamp mill using the oil flotation process and having a daily capacity of 100 tons. This mill was erected late in 1915. It is near a dump of 50,000 tons of 16 to 18 ounce silver ore. A small quantity of silver concentrate was shipped.

Bruner district.—The Big Henry, Silent Friend, and Duluth properties have been consolidated with the Paymaster. One test shipment of gold ore was made in 1915.

Bullfrog district.—Six operators produced 16,462 tons of ore containing $79,020 in gold, 7,079 ounces of silver, and a little copper and having a total value of $82,632, or an average of $5.02 per ton. The larger part, or 16,257 tons, was milled at gold and silver plants, and 205 tons of ore, containing gold, silver, and a little copper, was shipped to the smelter. The greater part of the ore came from the Sunset property and was treated in the 50-ton cyanidation plant. The Pioneer Consolidated, Polaris, and New York mines were also producers. Lessees operated on the Montgomery Shoshone property.

Cloverdale district.—The Orizaba property and one other produced silver ore, which was shipped to the smelter.

Ellendale district.—One property in the district yielded milling ore which produced gold and silver bullion and a small quantity of concentrate.

Fluorine district.—Lessees on the Bull Moose property operated two months in the year and shipped a small quantity of gold ore.

Golden Arrow district.—The Colter mine, which is opened by two inclined shafts 520 and 140 feet deep, produced a few tons of gold ore.

Johnnie district.—The new owners of the Johnnie mine overhauled the amalgamation mill and treated a few tons of gold ore. The shaft of the mine was being retimbered and the property put in shape for steady production.

Manhattan district.—Nineteen deep mines and 43 placer producers reported gold and silver amounting to $294,769, against an output in 1914 valued at $276,078. In 1915 there were 46,990 tons of ore milled, which yielded by amalgamation and cyanidation bullion containing $160,064 in gold and 2,621 ounces of silver, valued in all at $161,393, or an average value per ton of $3.43. The total placer bullion amounted to $132,132 in gold and 2,454 ounces of silver, against a production in 1914 of $130,371 in gold and 2,323 ounces of silver. The deep-mine output in 1914 was valued at $143,002 in gold and 2,548 ounces of silver, or an average per ton of $3.63. The Big Pine property, operated by lessees, yielded the largest quantity of ore and bullion. The same lessees also leased the Gold Crater, Dexter, and Big Four mines. The ore was treated in the 200-ton amalgamation mill. Other producers of importance were the White Caps, Cornucopia, April Fool, Little Grey, Manhattan Consolidated, and Mustang properties. The placers having the largest production were the Arlington, Last Chance, Top Knob, Amboy, African, and Bulldog. An account of the developments and production in the district is given in a recent article.[1]

Three ore bodies have been developed in the White Caps property; the eastern is much the largest as yet developed. It is about 130 feet long and in places is 24 feet between walls, the average width being 10 feet. From the middle ore body a large quantity of rich ore has been mined. West and south from the middle ore body, nearly 200 feet distant, another large vein has been exposed. From the bottom or 200-foot level (vertical) this western ore body proves to be about 80 feet long, averaging 8 feet in width for most of its length, although in one place it is more than 20 feet wide. A raise proves it to be "blind," the ore body ending about 30 feet below the surface.

The company's records show that 19,909 tons has been mined during the past three years, mostly by lessees, averaging $19.94 per ton. On the surface there is now about 6,000 tons of ore awaiting milling facilities. The White Caps Co. has installed a complete mine equipment. A new vertical shaft has been sunk in the hanging wall of the ore bodies in solid ground.

The Manhattan Consolidated property is in close proximity to the White Caps, and has developed a large ore body somewhat similar in character to that of the White Caps. The Consolidated has produced 9,075 tons of ore, valued at $127,000.

Litigation Hill joins the Consolidated on the west. The hill is about 2,500 feet long, of rounded nature, rising from the gulches on each side for a height of about 100 feet for most of its length, but at its eastern crest being about 250 feet from the floor of the valley. On this hill are found the Earl, Manhattan Amalgamated, and Litigation Hill Merger properties, consisting of five claims. A well-defined bed of limestone traverses the full length of the above-mentioned hill, the course of the bed being east and west, with an average width of over 200 feet. * * *

[1] Nash, Percival, Manhattan, Nev.: Min. and Sci. Press, Oct. 2, 1915, p. 523.

The Gold Hill area is in the center of the district, and at present is the scene of the most important mining operations, the Big Pine open-cut work. On the crest of Gold Hill is the Big Four property, with a fine mine equipment and a 10-stamp mill. The ore in this section is in a schist-zone, in places 50 feet wide. The Big Four has a shaft sunk to 500 feet. The first large profits from the property were made by lessees. In the first 100 feet of sinking 100 tons of ore was mined, averaging $325 per ton in the mill. The second lease, which brought the Big Four mine into prominence, produced nearly $500,000. After the company took over the property, ore worth about $85,000 was mined and milled.

The length of Gold Hill is about 3,000 feet. Directly south of the Big Four the Jumping Jack Co. cuts through with the eastern end of its claim into Gold Hill. It was from the second level of the Jumping Jack workings, in September, 1911, that Mushett & Wittenberg, the present operators of the Big Pine, cut through the south and east, crosscutting the mineralized schist zone. This zone has been proved from the Big Four to extend, following the line of the hill, for over 2,000 feet south, and from 50 to over 100 feet in width, with a developed depth of over 200 feet vertical.

The Big Pine claim for over 1,000 feet takes in the schist belt. About 350 feet from the north end line of the Big Pine is the Mushett & Wittenberg vertical shaft, sunk to 200 feet. Between the working shaft and the northern limits of the claim the ore found in the schist is being mined by glory-hole methods, being caved from the sides and ends of the opening in benches, dropped to the 200-foot level into chutes, from there trammed to the shaft, and then raised to the surface. During the past year the present glory hole has been worked, and its dimensions now show ore for 310 feet north from the shaft 50 feet wide and 200 feet deep, equal to 240,000 tons of ore, from the surface to the 200-foot level.

The mine and mill records show the following for July, 1915: The mill operated 86 per cent of the month, lost time being due to installation of new crusher, trommel, etc. A total of 4,409 tons passed through the tube mill at the rate of 7.42 tons per hour, 178 tons per day. There was 12,000 tons broken, hoisted, and crushed during July. The tailing averaged 40 cents per ton. The highest heads in the mill averaged $5.60, and the lowest averaged $2.20 per ton. The actual operating, mine and mill, cost during July—including labor of installation, additional machinery, electric power, explosives, incidentals, etc., and the cost of development, south drift from 200-foot level—shows an average of 46 cents per ton hoisted and passed through the crusher.

* * * The Dexter Union Mines Co. has the largest holdings in the district, owning 16 patented claims. The Union Four claim, directly north and side lining the Litigation Hill, has produced the most ore of any of their claims. At the present time Dexter Fourteen claim, lying north of the Big Four property, and covering the northern slope of Gold Hill, is making a good production, the surface of the hill containing considerable placer gold, with deep placer workings in the main Manhattan gulch, across which the claim extends. * * *

West from Gold Hill is the Union Nine claim of the Manhattan Dexter Mining Co. This claim contains one of the strongest veins in the district. It was one of the first properties to be operated after the discovery of the Manhattan. About $500,000 is the known production by lessees of the company. * * *

Directly adjoining Union Nine northward is the Little Grey claim, now under development by the Nevada Mining & Development Co. A depth of over 300 feet has been reached in this property, and an ore body developed from that point for a length of 160 feet. * * *

Among the mills of the district is the Associated mill, a custom plant, close to the White Caps and Consolidated properties. This mill is equipped with an automatic sampler, 10 stamps, amalgamating plates, tube mill, complete cyanide plant, and refinery.

On the Union Four claim of the Dexter-Union Mines Co. a 10-stamp custom mill with straight amalgamation is being operated by Whitman & Kane.

The Manhattan Milling & Ore Purchasing Co. owns a 10-stamp mill, sampler, tube mill, and cyanide plant situated on the Wolftone claim close to the Little Grey.

The largest mill at Manhattan is the War Eagle. It has 20 stamps, 2 tube mills, amalgamating plates, and complete cyanide plant. The mill is situated on the Mustang property, a low hill directly opposite the Little Grey and Dexter properties, but with Manhattan Gulch between them.

Milletts district.—A small quantity of ore from the Mammoth Contact property yielded gold.

Reveille district.—Lead ore from the property of the Southwestern Nevada Mines Co. was shipped to the smelter in 1915.

Round Mountain district.—Two deep mines yielded 50,006 tons of ore, producing bullion amounting to $263,032 in gold and 6,891 ounces of silver, valued in all at $266,526, or an average value of $5.33 per ton. The bullion recovered from 4 placers amounted to $72,612 in gold and 2,008 ounces of silver. The deep mines producing were the Round Mountain and Fairview properties. Considerable gold was also recovered from the placers of the Round Mountain Mining Co., which operated the property instead of leasing it as in former years. According to a statement by the company [1] it sold gold and silver bullion valued at $142,569.77, which was recovered from 25,345 tons of ore averaging $5.63 per ton. The mining and milling costs were $4.10 per ton, and the net operating income amounted to $1.63 per ton of ore treated. From placer bullion sales a partial clean-up of 18,150 yards of gravel netted the company $33,102.04, or an average of $1.82 per yard. The placer operating cost averaged 49 cents per yard. Preparations for a larger output of bullion were made by the expenditure of $192,887.78 for the Jett Creek pipe line, water rights, and placer equipment.

Stonewall district.—Only a few tons of gold ore were shipped from one property in the district in 1915.

Tonopah district.—From 1904 to the end of 1915 the mines of the district produced 3,858,464 tons of ore, containing $21,491,762 in gold, 98,162,950 ounces of silver, 12,113 pounds of copper, and 214,523 pounds of lead, valued in all at $77,280,916. The copper and lead was from properties closely adjoining the district. The total production shown by years may be consulted in Mineral Resources, 1914, part 1, page 702.

Metal production of Tonopah district, Nevada, 1904–1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	23	531,278	$2,648,833	11,388,452	2,284	924	$8,946,987
1915	22	516,337	2,228,983	10,171,374	.....	.....	7,385,870
Decrease, 1915	.....	14,941	419,850	1,217,078	2,284	924	1,561,117
Total, 1904–1915	.....	3,858,464	21,491,762	98,162,950	12,113	214,523	77,280,916

There were 22 producers reporting in 1915 an output amounting to $7,385,870 against an output by 23 producers in 1914 amounting to $8,946,987. The quantity of ore mined decreased from 531,278 tons in 1914 to 516,337 tons in 1915. The total average recovery value per ton of the ore produced was $14.30, against an average recovery value of $16.84 in 1914. Nearly all the ore, or 515,628 tons, was treated in cyanidation plants, some of which were equipped for concentration. Altogether 1,398 tons of gold and silver concentrates were produced. The mill bullion produced amounted to 104,172.53 ounces of gold and 9,607,053 ounces of silver, and the concentrates contained 3,574.70 ounces of gold and 545,566 ounces of silver. Only 18 tons of ore, containing a small quantity of gold and silver, were shipped to smelters. The average bullion recovery per

[1] Round Mountain Mining Co. typewritten statement for 6 months ending Sept. 30, 1915.

ton of ore cyanided was valued at $13.62, and the average value of the concentrates per ton was $250.71. There were 378 tons of sweepings from the mill ponds, some of it being re-treated and the remainder shipped to the smelter. The sweepings contained 148.16 ounces of gold and 20,765 ounces of silver. The principal properties producing in the district, in order of size of output, were the Belmont, Tonopah Mining, Extension, Jim Butler, West End, Montana Tonopah, Midway, Merger, Halifax, and North Star.

The Tonopah Belmont mine[1] during its fiscal year produced 211,225 wet tons of crude ore, from which 19.88 per cent of rock was culled, leaving 164,972 dry tons which, with 185 tons drawn from the ore stock, were treated at the mill by cyanidation. Altogether 165,157 dry tons of ore were milled, averaging per ton 0.196 ounce of gold and 19.60 ounces of silver and valued at $13.88, compared with the average of the previous year of 0.234 ounce of gold and 22.34 ounces of silver, valued at $16.747. The following is an extract from the company's annual report:

The total net operating costs (inclusive of miscellaneous earnings) were $7.093 per ton. The metallurgical losses (in mill tailings) were $0.965 per ton, and the metal losses (in sales of concentrates) were $0.076 per ton. Total costs and losses were $8.223 per ton, and profit per ton (inclusive of miscellaneous earnings) was $6.003 per ton. The percentage of profit from the Tonopah operation was 42.46 per cent.

The metals recovered by the milling operation at Tonopah aggregated 31,112.429 ounces gold and 2,968,564.78 ounces silver. The entire gold production was sold at an average of $20.56 per ounce (29,112.051 ounces in bullion at $20.6718 per ounce, and 1,988.478 ounces in concentrates at $19.06 per ounce, and 11.900 ounces in slags at $19 per ounce). Of the year's production of 2,968,564.78 ounces of silver, the silver content of the concentrates and slags—356,533.84 ounces—was sold to the smelters at an average of 51.746 cents per ounce. The production of silver as bullion was 2,612,030.94 fine ounces. At the beginning of the year there was unsold silver bullion, from Tonopah operations, in storage amounting to 1,646,099.08 fine ounces. From the total of 4,258,130.02 fine ounces (on hand March 1, 1915, and produced during the year), 3,385,014.94 fine ounces have been sold, at an average price of 51.76 cents per ounce, leaving 980,793.67 fine ounces in storage. * * *

In the past five years your Belmont mine has produced 19,297,353 ounces of silver, or 5.66 per cent of the total production of the United States, and 1.77 per cent of the total production of the world for the same period. * * *

The ore reserves of the Tonopah property, estimated as of March 1, 1916, comprise 118,597 tons of positive ore, 643 tons of probable ore, and 22,924 tons of possible ore, an aggregate estimated reserve of all classes of ore of 142,164 tons. * * *

During the fiscal year the direct mining cost per ton of ore was $3.883, a reduction from the similar cost of the previous year of $0.061 per ton. The indirect mining cost was $0.283 per ton of ore, a reduction from the similar cost of the preceding year of $0.086 per ton. Total mining costs were $4.166 per ton of ore, or $0.147 per ton lower than for the previous year. * * *

The Tonopah plant has been in continuous operation, on Belmont mine ores only, throughout the year, during which period 165,157 dry tons of ore, containing 32,348.289 ounces of gold, and 3,237,602.06 ounces of silver, were milled. The average grade of this tonnage was 0.196 ounce gold and 19.603 ounces silver, or $13.883 per ton. The gross value was $2,292,943.06, calculating silver in bullion at 50 cents per ounce. The average per ton value was lower than the per ton value of the previous year ($16.721) by $2.838 per ton, or by about 17 per cent.

The average recovery was 96.18 per cent of the gold content and 91.69 per cent of the silver content, or a combined extraction of 92.97 per cent. The combined extraction was two one-hundredths of 1 per cent less than the combined extraction (92.99 per cent) of the previous year. The tailings for the year averaged 0.0075 ounce in gold and 1.63 ounces silver, or $0.964 per ton (calculating gold at $20.00 and silver at 50 cents per ounce), as compared with $1.168 per ton for the preceding year. While the percentage of recovery, as above, is slightly lower than the previous year, the fact that a considerably lower grade (per ton) tailing was produced, indicates an actually more efficient treatment.

[1] Tonopah Belmont Development Co. Thirteenth Ann. Rept., for year ending Feb. 29, 1916.

The average number of stamps dropped was 50, of a total of 60 stamps, and the average 24-hour duty per stamp was 9.15 tons. The average daily tonnage was 457.5 tons for the 361 days of operation.

The average direct milling cost was $2.366 per ton, or $0.210 per ton higher than the similar cost of the preceding year. The average indirect milling cost was $0.316 per ton, lower than the previous year's similar cost by $0.092 per ton. The average total milling cost was $2.682, or $0.118 higher than the similar cost ($2.564) of the previous year. The direct cost of production of the unit ounce of Doré bullion was $0.130, as compared with $0.104 in the previous year. * * *

The Miller's plant was operated throughout the year as a custom mill, treating 56,730 dry tons of custom ore, of an average per ton content of 0.309 ounce gold and 25.01 ounces silver and of a gross value of $1,073,516.86. Recoveries of 93.75 per cent of the gold and of 90.13 per cent of the silver were made, the combined recovery being 91.33 per cent of the total value. * * *

The average direct milling cost was $3.57 per ton, as compared with $3.796 per ton for the preceding year. * * *

The increased recoveries and decreased costs were due almost entirely to the installation of the continuous decantation system, in the previous year, in place of the old filter method of operation. * * *

During the year 1,018.07 tons of "sweepings" have been recovered, under a leasing system, from the impounded Tonopah tailings. This tonnage contained average per ton values of 0.343 ounce gold and 55.92 ounces silver and a total gross value of $34,328.28. The net return from the "sweepings" was $4,836.21.

There were mined from the Tonopah Mining Co.'s property,[1] according to its annual report, 96,735 dry tons of ore, averaging $14.41 per ton in gold and silver; and 39,462 dry tons of dump ore, averaging $11.09 per ton, were shipped to the mill. Altogether there were treated at the cyanide mill 136,246 tons of ore averaging in value $13.66, from which the mining and milling cost of $6.81 and the cost of marketing the mill products, and tailing losses, were deducted, leaving a profit of $4.77 per ton.

The Tonopah Extension property[2] during the fiscal year yielded 91,981 tons of ore, all of which was treated at its mill. The company sold 2,106,518.91 ounces of silver and 20,575.60 ounces of gold, having a total value of $1,532,900.79. The total gross value of the ore milled was $18.038 per ton. The mining cost (including development) was $4.614; milling costs $4.478; metal losses in milling, $1.372; marketing bullion, $0.50; in all amounting to $10.965, which, deducted from the gross value, gave a profit of $7.073 per ton. On account of the improved condition of the ore reserves, arrangements have been made by the company to increase the capacity of the cyanide mill about 30 per cent. It was expected that this addition would be completed and in operation by July 1, 1916.

At the West End property 56,976 dry tons of ore were treated in its cyanide mill. The recovered bullion contained 13,219.12 ounces of gold and 1,210,037.57 ounces of silver. The annual printed report of the company[3] gives the following data concerning its mill extraction:

The gold extraction for the year of 94.80 per cent and the silver extraction of 90.88 per cent are the highest respective extraction figures yet attained at the West End mill. The combined extraction was 90.92 per cent of the metallic content and 92.10 per cent of the money value of the ore. This last extraction figure of 92.1 per cent is the accepted method of reporting extraction. It is to be further noted that this extraction was made by cyaniding only. Concentration was abandoned in 1914, as the additional gross extraction made by its aid was overbalanced by the 8 to 10 per cent marketing cost on the values removed in the concentrate. The cost in 1915 for

[1] Tonopah Mining Co. of Nevada Fourteenth Ann. Rept., for year ending Feb. 29, 1916.
[2] Tonopah Extension Mining Co. Ann. Rept. for year ending Mar. 31, 1916.
[3] West End Consolidated Mining Co. Ann. Rept. for year ending Dec. 31, 1915.

marketing the products of cyaniding was only 1.7 per cent of the gross value of the ore, giving the high net extraction of 90.4 per cent. This net extraction of 90.4 per cent is also the highest annual figure we have yet attained, and is considerably above the average 1915 figure of 89.75 per cent for the mills of the Tonopah district.

The daily tonnage treated was 156 tons, which required 22.6 stamps dropping continuously, giving an average of 6.9 tons per day to the stamp.

During the last six months of the year the average value of the ore treated was $20.10. The ore was a composite of Tonopah ores, being mainly sulphide ores. A gross extraction of 92.1 per cent was obtained, giving a net extraction of 90.5 per cent. Although concentration was not used, the average titration of the strongest solution in the mill, being that of No. 1 Agitator, was 3.5 pounds potassium cyanide and 0.7 pound of protective sodium hydrate. The consumption of cyanide for the period was 2.9 pounds of sodium cyanide and 1.16 pounds of zinc shavings. These results are worthy of mention, as they mark a high point in the treatment of Tonopah ores without concentration.

Tybo (Keystone) district.—Operators of three properties shipped 130 tons of ore, containing $1,941 in gold, 2,189 ounces of silver, 2,135 pounds of copper, and 13,142 pounds of lead, valued in all at $4,042, or an average value of $31.09 per ton.

Volcano district.—Ore from the Bannock property, containing principally gold and some silver, was shipped in 1915.

ORMSBY COUNTY.

Four deep-mine producers reported 507 tons of ore, which is 467 tons more than was produced in 1914 by the same number of operators. The total average value per ton decreased from $10.70 in 1914 to $6.46 in 1915. The ore in 1915 contained some copper and only $3.98 per ton in gold and silver. Included in total output, were 454 tons of old tailings re-treated by cyanidation and 53 tons of copper ore shipped to the smelter.

Carson River district.—The Brunswick mine was the producer of a small quantity of oxidized copper ore, which was shipped to the smelter. Old tailings were reworked in a small cyanide plant erected in 1915.

STOREY COUNTY.

Mine production in Storey County, Nev., in 1914 and 1915.

Year.	Number producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	
1914	36	103,406	$434,387	278,599	1,094	.....	$588,598
1915	23	85,144	298,990	156,645	531	4,873	378,731
Increase or decrease, 1915	.....	−18,262	−135,397	−121,954	−563	+4,873	− 209,867

Twenty-three producers reported the production of 85,144 tons of ore. This is 18,262 tons less than was reported by 36 producers in 1914. The total average value per ton decreased from $5.69 in 1914 to $4.45 in 1915. Practically all of this value was for gold and silver content. The bulk of the ore, 79,159 tons, was treated at gold and silver mills, yielding $251,910 in gold and 128,093 ounces of silver, having an average value per ton of $4. There were 1,402 tons treated at concentration mills, from which was recovered 386 tons of con-

centrates, containing $44,013 in gold, 25,841 ounces of silver, 531 pounds of copper, and 4,873 pounds of lead, valued in all at $57,436, or an average value per ton of $148.79. The ore of shipping grade, 48 tons, contained gold and silver and had an average value per ton of $92.52. No placer production was reported.

Comstock district.—The ore mined by 23 producers in 1915 was 85,144 tons, containing $298,990 in gold, 156,645 ounces of silver, 4,873 pounds of lead, and a small quantity of copper, valued in all at $378,731, or an average value per ton of $4.45. The principal producers were the Jacket-Crown Point-Belcher Mines Co., Silver Hill, Cedar Hill, Potosi & Chollar, Ophir, and Union Consolidated.

WASHOE COUNTY.

The ore output of 22 producers aggregated 5,118 tons, 177 tons less than was produced by 45 producers in 1914. The total average value per ton decreased from $14.60 in 1914 to $11.65 in 1915, and the gold and silver value in the ore from $11.93 to $9.55. The greater part of the ore was milled, yielding lead concentrate containing principally silver having an average value of $101.95 per ton. Ore treated at gold and silver mills, 2,020 tons, produced gold and silver bullion amounting to $26,901 in gold and 734 ounces of silver, with an average value per ton of $13.50. The reported output of three placers amounted to $160 in gold and 2 ounces of silver.

Leadville district.—There were three properties producing in 1915. The Tohoqua mine and concentration mill were operated and a considerable quantity of lead concentrates containing silver was shipped to the smelter.

Peavine district.—The Emily May property was operated by a lessee and yielded copper ore containing silver. A small production of copper ore was made from the Red Metals property.

Rainbow district.—The Ethel property, on which a little development work was done, produced a small quantity of gold and silver bullion from cyanidation tests.

Washoe district.—Ore treated in an arrastre on the Last Chance property and a small quantity of copper ore shipped from the Oregon claim constitute the total output of the district in 1915.

West Comstock district.—A 10-stamp mill was under construction on the property of the Washington-Nevada Development Co. In testing the ore a small quantity of gold bullion was produced.

White Horse district.—All the ore produced in the district (1,307 tons) was treated at milling plants and yielded bullion amounting to $22,146 in gold and 461 ounces of silver, valued in all at $22,380, or an average value per ton of $17.12. Half of the ore was produced by lessees from the Springfield-Nevada property, which is equipped with an amalgamation plant containing two 3½-foot Huntington mills. Other producers were the Renegade, Cabin No. 2, Hutchinson, and Ruth R. properties.

WHITE PINE COUNTY.

Mine production in White Pine County, Nev., in 1914 and 1915.

Year.	Number of producers.	Ore.	Gold.[a]	Silver.[a]	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds.*	
1914	31	2,751,473	$364,912	105,281	51,176,830	915,602	.....	$7,265,360
1915	51	3,207,981	620,579	112,934	64,682,966	1,603,740	42,651	12,078,021
Increase, 1915	.....	456,508	255,667	7,653	13,506,136	688,138	42,651	4,812,661

[a] Includes placer production.

The greater part of the ore mined in the county is produced from one property. There were 50 producers reporting the production of 3,207,981 tons of ore, or 456,508 tons more than was produced in 1914, as reported by 26 operators. The total average value per ton increased from $2.64 in 1914 to $3.76 in 1915, and the gold and silver value in the ore from 15 to 21 cents. The bulk of the ore, 3,173,461 tons, was treated at concentration mills, yielding 438,142 tons of copper concentrate. A small quantity of lead concentrate was produced at one of the mills. The total average value per ton, including the lead, was $26.48. There were 32,938 tons of ore directly smelted, which contained $65,597 in gold, 36,797 ounces of silver, 1,713,345 pounds of copper, 1,218,449 pounds of lead, and 42,651 pounds of zinc, valued in all at $446,644, or an average value per ton of $13.56. There were 1,474 tons of old tailings and slag resmelted, yielding gold, silver, copper, and lead. Gold and silver bullion was produced from 108 tons of ore treated at milling plants. The placer output amounted to $2,395 in gold and 21 ounces of silver, against an output reported in 1914 of $2,537 in gold and 20 ounces of silver.

Aurum district.—The Greek-American property was the producer of a small quantity of lead ore.

Cherry Creek district.—Altogether 553 tons of ore were reported by 9 producers in 1915, containing $44,021 in gold and 9,886 ounces of silver, and one small lot of this ore contained a little copper and lead, valued in all at $49,061, or an average value per ton of $88.72. The larger part of the ore, or 500 tons, containing principally gold and silver, was of shipping grade, and 53 tons were milled, yielding gold and silver bullion. The district's production was made up largely of small lots of ore from various properties, shipped by lessees. A small quantity of bullion was recovered from ore mined from the Gold Nugget property.

Duck Creek district.—Thirteen producers reported the production of 472 tons of ore, containing $4,048 in gold, 4,340 ounces of silver, 2,063 pounds of copper, and 354,840 pounds of lead, valued in all at $23,287, or an average value per ton of $49.35. Of the ore 409 tons was shipped and 48 tons was concentrated, yielding some lead concentrate. A small quantity of ore was also tested by amalgamation. The Cuba produced lead sulphides carrying silver, and the Frederick group yielded concentrating lead ore. Lessees working on several other properties made up the total output of the district.

Eagle district.—Lead ore containing a little silver, mined from the Dandy property, was shipped to the smelter.

Granite (Steptoe) district.—The Royal property produced a small quantity of gold from ore treated in a 5-stamp mill by lessees.

Hunter district.—Copper-lead ore and a small quantity of slag were shipped from the Vulcan property, which was operated by lessees.

Osceola district.—A small quantity of gold-silver ore was shipped from one property in the district. Some placer bullion was produced also.

Pinto district.—The Washington property yielded a small quantity of lead ore containing silver.

Robinson (Ely) district.—From 1908 to the end of 1915 this district has yielded 19,680,158 tons of ore, containing $3,148,777 in gold, 603,798 ounces of silver, 458,268,306 pounds of copper, 1,400,345 pounds of lead, and 42,651 pounds of zinc, valued in all at $69,845,079.

Mine production of Robinson district, Nev., 1904–1915.

Year.	Number of producers.	Ore.	Gold.	Silver.	Copper.	Lead.	Zinc (spelter).	Total value.
		Short tons.		*Fine ounces.*	*Pounds.*	*Pounds.*	*Pounds*	
1914	2	2,749,913	$352,340	52,729	51,089,921	.....	.....	$7,176,459
1915	14	3,206,133	568,130	82,281	64,661,610	654,905	42,651	11,961,699
Increase, 1915	.....	456,220	215,790	29,552	13,571,689	654,905	42,651	4,785,240
Total, 1904–1915	.....	19,680,158	3,148,777	603,798	458,268,306	1,400,345	42,651	69,845,079

The largest producer in 1915 was the Nevada Consolidated, and considerable output was reported by the Consolidated Coppermines Co., controlling the Giroux and Ora mines. A few tons of copper ore were shipped from the McDonald Ely, and some slag from the old Chainman property.

A large quantity of "porphyry" copper ore from the Nevada Consolidated mine [1] was treated during the year. The net production of copper in 1915 was 62,726,651 pounds, compared with 49,244,056 pounds in 1914. The 1915 output represents more nearly the normal production, as the company curtailed its operations approximately 50 per cent of the normal capacity in 1914. Some details of the operations, taken from the company's annual published report, follow:

During the year active mining operations were started in the Ruth mine by the "caving" system, and, since June, 86,029 dry tons of ore have been shipped to the concentrator, averaging 2.28 per cent copper. No mining during the year was carried on in the Veteran. Steam-shovel operations were carried on in the Eureka, Hecla, and Liberty pits. The major portion of the ore was taken from the Liberty and Hecla, the proportions being as shown below. Owing to the favorable financial conditions and the increased demand for copper, the ore production was greatly increased during the year 1915, the tonnage mined being 16.73 per cent more than in the previous year.

The following table shows the ore mined and shipped to the concentrator during 1914 and 1915.

[1] Nevada Consolidated Copper Co. Ninth Ann. Rept., for year ending Dec. 31, 1915.

Operations of Nevada Consolidated copper mine, 1914–15.

	1914		1915	
	Short tons.	Percentage of copper.	Short tons.	Percentage of copper.
Eureka pit	578,981	1.405	432,600	1.52
Liberty-Hecla pits	1,934,260	1.405	2,559,182	1.52
Ruth			86,029	2.28
Veteran	123,324	3.063		
	2,636,565	1.483	3,077,811	1.54

Siliceous carbonate ore amounting to 26,258 dry tons and averaging 3.48 per cent copper was crushed and delivered to the smelter. All of this, with the exception of 1,083 wet tons mined in the pit during the year, was taken from the storage piles at the mine. * * *

The direct mining cost by steam shovel for the Eureka, Hecla, and Liberty pits was 15.24 cents. * * *

The redemption costs for the removal of the overburden were added to the regular mining costs and apportioned as follows: Per ton of dry ore mined, Eureka, 15 cents; Liberty, 22 cents; and Hecla, 30 cents.

As stated in former reports, the reason for the differences in redemption costs is due to the greater amount of overburden and waste from slopes to be removed per ton of ore obtained from the Hecla and Liberty than from the Eureka. * * *

Cost of mining carbonate ore was 46.1 cents per wet ton as against 62.9 cents per wet ton in the year 1914.

Operations of Nevada Consolidated mill in 1915.

Ore treated, dry	tons	3,081,520
Average copper assay	per cent	1.54
Percentage of extraction, copper		70.18
Ratio of concentration		7.18
Assay value, gold	ounces	0.017
Assay value, silver	do	0.042
Percentage of extraction, gold		49.47
Percentage of extraction, silver		51.34
Average copper in concentrates		7.77
Average gold and silver recovered per ton	cents	18.56

Owing to curtailment in the latter half of the year 1914, the tonnage for 1915 was considerably greater, the increase being 441,226 tons. The average per cent copper contained in the concentrates was appreciably greater in 1915 than in 1914, being 6.145 per cent in 1914 and 7.77 per cent in 1915. * * *

The yield for the year 1915 of sulphide ore mined and treated and from siliceous carbonate ore delivered to the smelter was 62,726,651 pounds of fine copper.

The average cost per pound of copper was 8.67 cents, and deducting miscellaneous earnings this is reduced to 8.23 cents. These costs include all possible charges. * * *

The net profit for the year available for dividends amounted to $5,905,601.87.

From the beginning of operations to December 31, 1915, there have been sold by the company 391,593,615 pounds of copper at an average price of 14.128 cents per pound, total realized value, $55,324,810.80.

Schellbourne district.—The Pride of the Hills claim yielded a small quantity of lead ore, containing silver, and some lead ore was also shipped from one of the prospects of the district.

White Pine (Hamilton) district.—Six deep-mine producers reported 561 tons of ore, containing $270 in gold, 11,981 ounces of silver, 11,508 pounds of copper, and 494,578 pounds of lead, valued in all at $31,603, or an average value per ton of $56.33. The larger part, or 441 tons, was shipped to smelter and 120 tons were treated at a concentration plant, yielding lead concentrate. The principal producers of lead ore were the Grand Prize, Jennie A., and Young Treasure properties. Milling ore yielding concentrate was produced from the Eureka property.

COPPER.

By B. S. Butler.

INTRODUCTION.

In the production of metallic copper suitable for commercial purposes at least three distinct processes are usually required, namely, mining, smelting, and refining. The Lake Superior native copper district is the only important producer where these three processes are not entirely distinct. It is possible, therefore, to ascertain the copper output of the country by collecting statistics from the mines, from the smelters, and from the refineries, and each of these sets of figures has its advantages. The mine figures have the advantage of giving the most accurate distribution of the production but are less accurate in total quantity of copper recovered; the smelter figures permit of reasonably accurate distribution and also furnish the actual recovery of copper from the ores treated during the year; the refinery figures furnish the best measures of the copper made available for commercial uses during the year, but at this stage of manufacture the accurate distribution to the State of origin, or even the separation of copper derived from domestic and from foreign sources, is uncertain.

Statistics for 1915 showing the production of each of these stages of manufacture have been collected by the United States Geological Survey, and are presented in the following report.

As the same material passes through the three processes of manufacture at successive periods, usually requiring two to three months from the time it is taken from the mine before it reaches the stage of refined copper, the year's production as recorded for the different stages does not represent the same materials—that is, the refinery production for the calendar year 1915 represents the mine production from about October 1, 1914, to October 1, 1915. The three sets of figures representing the successive stages of manufacture do not, therefore, necessarily agree, although they should not differ greatly if the condition of the industry is normal. The mine figures and the smelter figures will differ by the difference in the quantity of ore, matte, and other materials in stock at the beginning and at the end of the year and by the difference in the quantity of copper reported by the mines and that recovered by the smelters. This difference is due to the fact that considerable copper is recovered from sulphur, lead, zinc, and siliceous ores carrying values in copper so low that the mines do not receive pay for and frequently do not report the copper content of the ore, although it is eventually recovered by the smelters. The smelter and refinery figures will differ by the increase or decrease in stock of blister and other unrefined forms of copper at the beginning and at the end of the year and by the loss in refining.

As the smelter production permits reasonably accurate distribution as to the source by States and also gives the actual output of copper, it is adopted in this report as the production of the country. It is made up of the production of blister copper and of furnace-refined or ingot copper of the Lake district.

SUMMARY OF STATISTICS.

Summary of statistics of the copper industry in the United States in 1912, 1913, 1914, and 1915.

	1912	1913	1914	1915
Production of copper:				
Smelter output.....pounds..	1,243,268,720	1,224,484,098	1,150,137,192	1,388,009,527
Mine production.....do....	1,249,094,891	1,235,569,727	1,148,431,437	1,488,071,528
Refinery production of new copper—				
Electrolytic.....do....	914,935,371	1,022,497,601	991,573,073	1,114,345,342
Lake.....do....	231,112,228	155,715,286	158,009,748	236,757,062
Casting and pig.....do....	57,629,296	58,611,026	60,840,368	36,603,119
Total domestic.....do....	1,203,676,895	1,236,823,913	1,210,423,189	1,387,705,523
Total domestic and foreign.....do....	1,568,104,478	1,615,067,782	1,533,781,394	1,634,204,448
Total new and old copper.....do....	1,843,000,000	1,888,000,000	1,790,000,000	2,026,000,000
Total ore produced.....short tons..	35,671,028	36,361,101	35,187,118	43,415,133
Copper ore produced.....do....	35,656,414	36,336,682	35,175,541	43,404,182
Average yield of copper.....per cent..	1.71	1.67	1.60	1.66
Imports.....pounds..	410,240,295	408,778,954	306,350,827	315,698,449
Exports.....do....	775,000,658	926,241,092	840,080,922	681,953,301
Consumption:				
Total new copper.....do....	775,978,332	812,068,639	620,445,373	1,043,461,982
Total new and old copper.....do....	1,051,000,000	1,085,000,000	968,000,000	1,435,000,000
World's production.....do....	2,259,101,580	2,198,732,130	.....	.....
Value of production in the United States.....	$205,139,338	$189,795,035	$152,968,000	$242,902,000

Production of copper in the United States in 1913, 1914, and 1915.

[Smelter output, in pounds fine.]

	1913	1914	1915
Alaska	23,423,070	24,985,847	70,695,286
Arizona	404,278,809	382,449,922	432,467,690
California	32,492,265	29,784,173	37,658,444
Colorado	9,052,104	7,316,066	7,272,178
Idaho	8,711,490	5,875,205	6,217,728
Maryland	.....	12,248	15,426
Michigan	155,715,286	158,009,748	238,956,410
Missouri	576,204	53,519	306,406
Montana	285,719,918	236,805,845	268,263,040
Nevada	85,209,536	60,122,904	67,757,322
New Mexico	50,196,881	64,204,703	62,817,234
North Carolina	180	19,712	33,383
Oregon	77,812	5,599	797,471
Pennsylvania	245,337	422,741	.....
Tennessee	19,489,654	18,661,112	18,205,308
Texas	39,008	34,272	38,971
Utah	148,057,450	160,589,660	175,177,695
Vermont	5,771	.....	23,995
Virginia	46,961	17,753	50,008
Washington	732,742	683,602	903,661
Wyoming	362,235	17,082	351,871
Undistributed	51,385	65,479	.....
	1,224,484,098	1,150,137,192	1,388,009,527

GENERAL CONDITION OF THE INDUSTRY.

After the beginning of the European war in August, 1914, many of the large copper companies of the United States curtailed their output by 30 to 50 per cent and many of the smaller companies ceased operations entirely. This condition prevailed through the last five months of 1914 and into 1915. Early in 1915 it became apparent that the requirements of copper for war materials would far exceed what had been generally anticipated, the price of the metal began to advance, and in consequence production increased. Both price and output continued to increase steadily and rapidly. Before the middle of the year most companies were operating at full capacity and in the second half of the year plants were pushed to the utmost, in some of them a high recovery of metal being sacrificed for a large output. The total output for the year was the largest in the history of the industry.

The average cost per pound of producing electrolytic and casting copper, as compiled from the annual reports of companies giving this item, was 7.86 cents. This compares with 8.62 cents in 1914, with 9.49 cents in 1913, and with 8.74 cents in 1912. The cost as indicated by these figures is doubtless below the actual average cost of all copper but probably represents the general trend of costs.

The average cost per pound of Lake copper, as compiled from the annual reports of companies giving this item, was 8.23 cents. In 1914 the cost was 10.93 cents; in 1913, 13.44 cents; and in 1912, 10.28 cents.

The decrease in cost in 1915 from 1914 was accomplished in spite of increase in wages and larger expenditures on development and construction in 1915. Not only were wages increased but there was doubtless a decrease in average efficiency of labor, as is common when it is in large demand. Notable improvement in metallurgical practice was made, but the effect of this will appear in the output for 1916 much more than in that for 1915. In 1915 such improvements as were installed were probably partly offset by the sacrifice of the best practices for large outputs.

The average selling price of electrolytic copper, as compiled from the reports of companies giving that item, was 17.33 cents a pound in 1915 and that of Lake copper was 17.79 cents. It is probable that the average profit per pound of copper produced was at least 8 cents. This would mean a profit for the industry of over $111,000,000. Several of the copper companies increased their dividends during the year, and practically all added largely to their reserve funds, so that most of them were greatly improved in financial position at the close of 1915.

The most satisfactory feature of the industry during the last few years has been the great improvement in metallurgical practices. The blast furnace that was long so large a factor in copper metallurgy has been in large part replaced by the reverberatory furnace. The silica-lined converter has in many plants given place to the more efficient basic-lined converter. The great increase in concentrating ore treated during recent years has served to emphasize the lamentably large losses by the older concentration processes, and the great increase in recovery effected by later improvements is most important and gratifying. The added recovery resulting from finer grinding in the Lake Superior district has already been felt. The flotation process, which promises almost a revolution in concentrating methods, had some influence on production in 1915 but will be more important in 1916 and subsequent years. Leaching processes, which a short time ago promised to take a prominent place in the industry, will probably be restricted to classes of ore not readily susceptible of treatment by the flotation process as at present developed. There seems to be a field, however, for leaching processes in the treatment of low-grade oxidized and partly oxidized ores. Plants were in process of construction during the year and others will doubtless follow.

Improved processes promise to add from 10 to 20 per cent to the recovery of metal from concentrating ores. This will be felt not only in the added production from the class of ores that could be treated by the less efficient methods but will doubtless lead to a lowering in the grade of material that can be treated and thus add largely to the ore reserves. It will also be possible to re-treat some of the tailings from earlier operations.

Exports of copper in unmanufactured form were much lower than in 1914. Domestic consumption, however, increased greatly and a

large part of the copper representing this increase was manufactured for export.

Stocks of refined copper held in the United States January 1, 1916, were greatly reduced from those held on the same date in 1915.

In all branches of the industry the capacity for production is the largest that it has ever been and is being further increased. Whether or not this increase can be continued or the present output maintained of course depends upon the future demand for the metal. As long as the great war continues there is bound to be a large demand for copper. Opinion differs greatly as to the conditions that will prevail at the end of the war. There will doubtless be a large demand for metals for the work of reconstruction. The disregard for cost that has prevailed during the period of destruction will not continue during the period of reconstruction, however, and unless the price of copper is much reduced from the present quotations other metals will be utilized where possible.

It seems reasonable to conclude, then, that if a market is to be found for the greatly increased output of copper from North America and South America, as well as from other parts of the world, it must be at a price lower than has prevailed during war times. This fact will be borne in mind by producers with whom profits are possible only at the present abnormally high price of metal.

PRODUCTION.

SMELTER PRODUCTION.

Magnitude and growth of production of copper in the United States from 1845 to 1915, inclusive.

[Values rounded.]

Year.	Production.	Increase.	Value.	Year.	Production.	Increase.	Value.
	Pounds.	*Pounds.*			*Pounds.*	*Pounds.*	
1845	224,000	.....	$45,000	1881	71,680,000	11,200,000	$13,046,000
1846	336,000	112,000	57,000	1882	90,646,232	18,966,232	17,313,000
1847	672,000	336,000	124,000	1883	115,526,053	24,879,821	19,062,000
1848	1,120,000	448,000	218,000	1884	144,946,653	29,420,600	18,843,000
1849	1,568,000	448,000	349,000	1885	165,875,483	20,928,830	17,915,000
1850	1,456,000	a112,000	320,000	1886	157,763,043	a8,112,440	17,512,000
1851	2,016,000	560,000	334,000	1887	181,477,331	23,714,288	25,044,000
1852	2,464,000	448,000	542,000	1888	226,361,466	45,440,942	38,029,000
1853	4,480,000	2,016,000	985,000	1889	226,775,962	414,496	30,615,000
1854	5,040,000	560,000	1,108,000	1890	259,763,092	32,987,130	40,523,000
1855	6,720,000	1,680,000	1,814,000	1891	284,121,764	24,358,672	36,368,000
1856	8,960,000	2,240,000	2,419,000	1892	344,998,679	60,876,915	40,020,000
1857	10,752,000	1,792,000	2,688,000	1893	329,354,398	a15,644,281	35,570,000
1858	12,320,000	1,568,000	2,833,000	1894	354,188,374	24,833,976	33,648,000
1859	14,112,000	1,792,000	3,104,000	1895	380,613,404	26,425,030	40,726,000
1860	16,128,000	2,016,000	3,709,000	1896	460,061,430	79,448,026	49,687,000
1861	16,800,000	672,000	3,696,000	1897	494,078,274	34,016,844	59,289,000
1862	21,160,000	4,360,000	4,655,000	1898	526,512,987	32,434,713	65,288,000
1863	19,040,000	a2,120,000	6,473,000	1899	568,666,921	42,153,934	97,242,000
1864	17,920,000	a1,120,000	8,422,000	1900	606,117,166	37,450,245	100,615,000
1865	19,040,000	1,120,000	7,473,000	1901	602,072,519	a4,044,647	100,546,000
1866	19,936,000	896,000	6,828,000	1902	659,508,644	57,436,125	80,460,000
1867	22,400,000	2,464,000	5,682,000	1903	698,044,517	38,535,873	95,632,000
1868	25,984,000	3,584,000	5,976,000	1904	812,537,267	114,492,750	104,005,000
1869	28,000,000	2,016,000	6,790,000	1905	888,784,267	76,247,000	138,650,000
1870	28,224,000	224,000	5,977,000	1906	917,805,682	29,021,415	177,136,000
1871	29,120,000	896,000	7,023,000	1907	868,996,491	a48,809,191	173,799,000
1872	28,000,000	a1,120,000	9,956,000	1908	942,570,721	73,574,230	124,419,000
1873	34,720,000	6,720,000	9,721,000	1909	1,092,951,624	150,380,903	142,084,000
1874	39,200,000	4,480,000	8,624,000	1910	1,080,159,509	a12,792,115	137,180,000
1875	40,320,000	1,120,000	9,152,000	1911	1,097,232,749	17,073,240	137,154,000
1876	42,560,000	2,240,000	8,937,000	1912	1,243,268,720	146,035,971	205,139,000
1877	47,040,000	4,480,000	8,937,000	1913	1,224,484,098	a18,784,622	189,795,000
1878	48,160,000	1,120,000	7,994,000	1914	1,150,137,192	a74,346,906	152,968,000
1879	51,520,000	3,360,000	9,582,000	1915	1,388,009,527	237,872,335	242,902,000
1880	60,480,000	8,960,000	12,943,000				
					21,384,084,239	.....	3,173,714,000

a Decrease.

The figures, except for 1915, are taken from the volumes of Mineral Resources of the United States. Statistics from 1882 to 1915, inclusive, are based on the returns to the United States Geological Survey by the copper-producing companies. Figures for the years prior to 1882 were compiled by the Survey from the best sources available. Reliable figures for years previous to 1845 are not obtainable. The year 1845, however, marks the entrance of the Lake Superior district into the ranks of producers and is really the beginning of important production of copper in this country. The industry has shown a steady and, since 1880 when Arizona and Montana became important producers, a very rapid growth.

Only seven times since 1880 has the annual production shown a decrease from that of the preceding year and in every instance the decrease has been slight and, with the exception of 1913, has been more than recovered in the following year. The years showing a decrease are 1886, 1893, 1901, 1907, 1910, 1913, and 1914. In several other years the increase has been slight. In most years in which there has been a decrease it may be attributed to a general condition of financial and business depression which has resulted in a decrease in the demand for copper and other materials necessary to the expansion of industries. In three years a slight decrease appears to have been due to the fact that the producing capacity of the country had been increased out of proportion to the demand for domestic consumption and export, and a temporary curtailment in production became necessary to permit the absorption of accumulated stocks. This, coupled with attempts at artificial control of prices, appears to have been the case in 1886 and also in 1901, and the decrease in production in 1910 may be attributed to a similar cause. The large increase in 1912 was due to the output from mines that reached the producing stage during 1912 or had previously made but relatively small production.

The total decrease in 1913 was really less than that of Michigan alone in that year, which was due to labor troubles. The decrease in 1914 can be attributed entirely to the European war, and the increase in 1915, which was greater than the total production of any year before 1890, is to be accounted for in the same manner.

The figures of smelter production for 1915 are based on returns made confidentially to the United States Geological Survey by all known smelting companies handling copper-bearing materials from the United States. To all companies and officials who have aided in furnishing this information and have given valuable time to answering inquiries concerning distribution of the output sincere thanks are extended. The following list gives the name of the owning or operating companies, the location, and the final copper product of smelting and refining plants treating material from the United States during 1915. It does not include lead and zinc plants that recovered copper as a by-product from mixed ores. Lists of lead and zinc smelters can be found in the reports on those metals.

Copper smelting plants that treated materials from the United States in 1915.

Location.	Company.	Final copper product.
Arizona:		
Clifton	Arizona Copper Co	Blister.
Do	Shannon Copper Co	Do.
Douglas	Calumet & Arizona Mining Co	Do.
Do	Copper Queen Consolidated Mining Co	Do.
Globe	Old Dominion Copper Mining & Smelting Co	Do.
Hayden	American Smelting & Refining Co	Do.
Humboldt	Consolidated Arizona Smelting Co	Do.
Clarkdale	United Verde Copper Co	Do.
Miami	International Smelting & Refining Co	Do.
Morenci	Detroit Copper Mining Co	Do.
California:		
Campo Seco	Penn Mining Co	Matte.
Kennett	Mammoth Copper Mining Co	Blister.
Martinez	Mountain Copper Co	Do.
Colorado:		
Ouray	Wanakah Mining Co	Matte.
Salida	Ohio & Colorado Smelting & Refining Co	Do.
Maryland:		
Baltimore	Baltimore Copper Smelting & Rolling Co	Electrolytic.
Michigan:		
Hancock	Lake Superior Smelting Co	Anodes and Lake.
Do	Quincy Mining Co	Do.
Houghton	Michigan Smelting Co	Do.
Hubbell	Calumet & Hecla Mining Co	Do.
Missouri:		
Sullivan	Missouri Copper Mountain Mining Co	Matte.
Montana:		
Anaconda	Anaconda Copper Mining Co	Blister.
Butte	East Butte Copper Mining Co	Do.
Great Falls	Anaconda Copper Mining Co	Blister and electrolytic.
Nebraska:		
Omaha	American Smelting & Refining Co	Blister.
Nevada:		
McGill	Nevada Consolidated Copper Co	Do.
New Jersey:[a]		
Chrome	United States Metals Refining Co	Electrolytic and casting.
Maurer	American Smelting & Refining Co	Electrolytic.
Newark	Balbach Smelting & Refining Co	Electrolytic and casting.
Perth Amboy	Raritan Copper Works	Electrolytic.
New Mexico:		
San Pedro	Santa Fe Gold & Copper Mining Co	Matte.
New York:		
Laurel Hill	Nichols Copper Co	Electrolytic and casting.
Tennessee:		
Copperhill	Tennessee Copper Co	Blister.
Isabella	Ducktown Sulphur, Copper, & Iron Co. (Ltd.)	Matte.
Texas:		
El Paso	American Smelting & Refining Co	Blister.
Utah:		
Garfield	Garfield Smelting Co	Do.
International	International Smelting & Refining Co	Do.
Virginia:		
West Norfolk	Norfolk Smelting Co	Matte.
Washington:		
Tacoma	Tacoma Smelting Co	Blister and electrolytic.
British Columbia:		
Anyox	Granby Consolidated Mining, Smelting, & Power Co.	Blister.
Grand Forks	do	Do.
Greenwood	British Columbia Copper Co. (Ltd.)	Do.
Trail	Consolidated Mining & Smelting Co. of Canada	Matte.

[a] This list does not include a smelter in New Jersey and one in Pennsylvania, both of which make blister from material solely of foreign origin.

During the year 41 copper smelting and refining plants treated material from the United States; of these, 37 were domestic plants and 4 were foreign.

The figures of production represent the actual smelter recovery. For Michigan it is the sum of furnace-refined copper and copper cast into anodes for electrolytic refining. As to blister copper, the figures represent the fine copper content. Some casting copper is produced direct from ore and matte, and this is included in the smelter production.

MINE RETURNS.

The figures of mine production are based on reports furnished to the United States Geological Survey by all mines producing copper in 1915. These mines reported 1,488,071,528 pounds of copper, or 100,000,000 pounds more than the smelters. The mines and smelters of several of the large copper producers are under the same management and their production is reported on the same basis. In the case of mines that ship to custom smelters or have only matting furnaces and ship their matte for conversion there is likely to be considerable discrepancy, as the mines may report a considerable quantity that has not reached the stage of blister by the close of the year and is consequently not included in the smelter production, or material that was reported by the mines in one year may be treated by the smelters the following year. This discrepancy is more pronounced if a market curtailment of production occurs at the beginning or at the close of the year, so that there is not the balance of overlap that occurs if the industry is in normal condition throughout the year. Considerable copper is recovered by the smelters from ore that are treated primarily for other metals, the copper content being so low that it is not paid for, and, consequently, is not always reported by the mines.

Copper produced from domestic ores as reported by mines, smelters, and refineries, 1906–1915, in pounds.

Year.	Mine.	Smelter.	Refinery.
1906	916,971,387	917,805,682	897,382,387
1907	847,151,015	868,996,491	826,622,390
1908	956,840,578	942,570,721	919,111,414
1909	1,126,521,126	1,092,951,624	1,065,564,921
1910	1,088,237,432	1,080,159,509	1,071,894,876
1911	1,114,764,197	1,097,232,749	1,101,270,803
1912	1,249,094,891	1,243,268,720	1,203,676,895
1913	1,235,569,727	1,224,484,098	1,236,823,913
1914	1,148,431,437	1,150,137,192	1,210,423,189
1915	1,488,071,528	1,388,009,527	1,387,705,523

The difference between the smelter and the refinery production is accounted for entirely by an increase in the stocks of blister copper plus the copper content of bluestone produced and the loss in refining.

It appears that although theoretically the output reported by the mines should be considerably in excess of that reported by the smelters, this difference in the last 10 years has been nearly balanced by copper recovered from lead, zinc, gold, silver, and sulphur ores, which carry so little copper that it is not paid for, and consequently has not usually been reported by the mines.

PRODUCTION BY STATES.

Twenty-one States and Territories contributed to the production of copper in 1915. The following table shows the mine and the smelter output of individual States for 1914 and 1915.

According to smelter returns, the four leading States—Arizona, Montana, Michigan, and Utah—produced 80.32 per cent of the total output in 1915; and the same States produced 82 per cent of the output in 1914; and the eight leading States, including Alaska, Nevada, New Mexico, and California, produced 97.53 per cent of the total output in 1915.

Copper produced in 1914 and 1915, according to smelter and mine returns, in pounds.

State.	1915				1914	
	Rank.	Percentage of total.	Smelter returns.	Mine returns.	Smelter returns.	Mine returns.
Alaska	5	5.09	70,695,286	86,509,312	24,985,847	21,450,628
Arizona	1	31.16	432,467,690	459,972,295	382,449,922	393,017,400
California	8	2.71	37,658,444	40,751,625	29,784,173	30,507,692
Colorado	10	.52	7,272,178	7,112,537	7,316,066	6,639,173
Idaho	11	.45	6,217,728	6,978,713	5,875,205	6,445,187
Michigan	3	17.22	238,956,410	265,283,378	158,009,748	164,344,058
Missouri	15	.02	306,406	402,160	53,519	44,463
Montana	2	19.33	268,263,040	267,231,014	236,805,845	233,229,640
Nevada	6	4.88	67,757,322	68,636,370	60,122,904	60,986,450
New Mexico	7	4.53	62,817,234	76,788,366	64,204,703	59,307,925
North Carolina	18	.....	33,383	17,170	19,712	20,434
Oregon	13	.06	797,471	451,172	5,599	39,248
Pennsylvania, Maryland, and Virginia	.....	.....	65,434	629,855	452,742	797,272
Tennessee	9	1.31	18,205,308	18,046,010	18,661,112	18,737,656
Texas	17	.....	38,971	42,491	34,272	23,760
Utah	4	12.62	175,177,695	187,671,188	160,589,660	152,034,002
Vermont	19	.....	23,995	79,700	.....	.....
Washington	12	.07	903,661	1,020,926	683,602	778,728
Wyoming	14	.03	351,871	447,246	17,082	17,421
Undistributed	.....	.....	.....	.....	65,479	10,300
	.....	.....	1,388,009,527	1,488,071,528	1,150,137,192	1,148,431,437

In the distribution of the blister output to the States of origin it is necessary to have reports not only from blister producers, but also from matte smelters, as the matte is credited by the smelter that converts it to the State from which it was received, although the matte smelter may have received its ores from several States. In the adjustment of the products of these matte smelters slight errors in the distribution of the blister production are probably introduced. Likewise, the distribution of copper derived from zinc residues is subject to some error.

The following table shows the production from 1845 to 1915 for each State for which separate statistics are available:

Copper produced in the United States, 1845–1915, in pounds.

State.	1845	1846	1847	1848	1849	1850
Michigan	26,880	58,240	477,120	1,032,640	1,505,280	1,281,280
Eastern States and unapportioned	197,120	277,760	194,880	87,360	62,720	174,720
	224,000	336,000	672,000	1,120,000	1,568,000	1,456,000

State.	1851	1852	1853	1854	1855
Michigan	1,744,960	1,774,080	2,905,280	4,074,560	5,808,320
Eastern States and unapportioned	271,040	689,920	1,574,720	965,440	911,680
	2,016,000	2,464,000	4,480,000	5,040,000	6,720,000

State.	1856	1857	1858	1859	1860
Michigan	8,211,840	9,531,200	9,157,120	8,926,400	12,069,120
Eastern States and unapportioned	748,160	1,220,800	3,162,880	5,185,600	4,058,880
	8,960,000	10,752,000	12,320,000	14,112,000	16,128,000

Copper produced in the United States, 1845–1915, in pounds—Continued.

State.	1861	1862	1863	1864	1865
Arizona	.....	80,000	.....	.....	.....
California	.....	2,600,000	2,200,000	4,800,000	3,600,000
Michigan	15,037,120	13,585,600	12,985,280	12,490,240	14,358,400
New Mexico	[a] 1,000,000,	.....	.....	.....	.....
Eastern States and unapportioned	762,880	4,894,400	3,854,720	629,760	1,081,600
	16,800,000	21,160,000	19,040,000	17,920,000	19,040,000

State.	1866	1867	1868	1869	1870
Arizona	.....	984,000	.....	.....	.....
California	2,600,000	1,400,000	1,300,000	575,000	55,000
Colorado	112,000	.....	50,000	102,000	182,500
Idaho	.....	.....	.....	9,000	.....
Michigan	13,749,120	17,525,760	20,935,040	26,624,640	24,622,080
Montana	.....	.....	4,000	8,000	.....
New Mexico	.....	.....	.....	.....	12,600
Utah	.....	.....	.....	.....	100,000
Eastern States and unapportioned	3,474,880	2,490,240	3,694,960	681,360	3,251,820
	19,936,000	22,400,000	25,984,000	28,000,000	28,224,000

State.	1871	1872	1873	1874	1875
Arizona	.....	840,000	.....	450,000	500,000
California	600,000	350,000	450,000	320,000	.....
Colorado	183,000	204,000	379,493	475,541	280,815
Idaho	.....	.....	.....	.....	.....
Michigan	26,748,080	24,552,640	30,089,920	34,332,480	36,039,360
Montana	.....	.....	100,000	.....	100,000
New Mexico	.....	.....	32,000	50,000	300,000
Nevada	.....	.....	144,000	370,000	.....
Utah	390,000	600,000	876,000	374,000	716,000
Eastern States and unapportioned	1,198,920	1,453,360	2,648,587	2,827,979	2,383,825
	29,120,000	28,000,000	34,720,000	39,200,000	40,320,000

State.	1876	1877	1878	1879	1880
Arizona	500,000	3,000,000	3,000,000	3,183,750	2,000,000
California	.....	500,000	400,000	512,000	1,000,000
Colorado	333,333	493,664	536,145	704,301	859,000
Michigan	38,370,300	39,025,280	39,690,560	42,848,960	49,736,960
Montana	520,000	400,000	350,000	500,000	1,212,000
New Mexico	308,000	.....	.....	4,055	.....
Nevada	.....	.....	.....	134,730	.....
Utah	946,000	642,000	764,000	258,000	86,000
Eastern States and unapportioned	1,582,367	2,979,056	3,419,295	3,374,204	5,586,040
	46,560,000	47,040,000	48,160,000	51,520,000	60,480,000

State.	1881	1882	1883	1884	1885
Arizona	8,000,000	17,984,415	23,874,963	26,734,345	22,706,366
California	500,000	826,695	1,600,862	876,166	469,028
Colorado [b]	884,000	1,494,000	1,152,652	2,013,125	1,146,460
Idaho	.....	.....	.....	46,667	40,381
Michigan	53,573,120	56,982,765	59,702,404	69,353,202	72,147,889
Montana	1,450,000	9,058,284	24,664,346	43,093,054	67,797,864
New Mexico	500,000	869,498	823,511	59,450	79,839
Nevada	.....	350,000	288,077	100,000	8,871
Utah	386,000	605,880	341,885	265,526	126,199
Washington	.....	.....	.....	.....	.....
Wyoming	.....	100,000	962,468	.....	.....
Eastern States and unapportioned	6,386,880	.....	.....	.....	.....
Eastern States	.....	1,555,000	612,124	904,423	211,602
Southern States	.....	400,000	395,175	317,711	40,199
Middle States	.....	294,695	324,706	232,114	190,641
Lead desilverizers and unapportioned	.....	125,000	782,880	950,870	910,144
	71,680,000	90,646,232	115,526,053	144,946,653	165,875,483

[a] Comprises period 1858–1861, inclusive.
[b] For several of the early years the production credited to Colorado included the yield from some ores of uncertain origin which were smelted in Colorado plants.

Copper produced in the United States, 1845–1915, in pounds—Continued.

State.	1886	1887	1888	1889	1890
Arizona	15,657,035	17,720,462	31,797,300	31,586,185	34,796,689
California	430,210	1,600,000	1,570,021	151,505	23,347
Colorado [a]	[b] 1,000,000	2,012,027	1,621,100	1,170,053	3,585,691
Idaho			50,000	156,490	87,243
Michigan	80,918,460	76,028,697	86,472,034	88,175,675	101,410,277
Montana	57,611,621	78,699,677	97,897,968	98,222,444	112,980,896
New Mexico	558,385	283,664	1,631,271	3,686,137	850,034
Nevada	50,000		50,000	26,420	
Utah	500,000	2,500,000	2,131,047	65,467	1,006,636
Washington					
Wyoming			232,819	100,000	
Eastern States	315,719	200,000	271,631	72,000	
Southern States	29,811		18,201	18,144	378,840
Middle States					
Lead desilverizers and unapportioned	691,802	2,432,804	2,618,074	3,345,442	4,643,439
	157,763,043	181,477,331	226,361,466	226,775,962	259,763,092

State.	1891	1892	1893	1894	1895
Arizona	39,873,279	38,436,099	43,902,824	44,514,894	47,953,553
California	3,397,405	2,980,944	239,682	120,000	218,332
Colorado [a]	6,336,878	7,593,674	7,695,826	6,481,413	6,079,243
Idaho	146,825	226,000	36,367		1,425,914
Michigan	114,222,709	123,198,460	112,605,078	114,308,870	129,330,749
Montana	112,063,320	163,206,128	155,209,133	183,072,756	190,172,150
New Mexico	1,233,197	1,188,796	280,742	31,884	143,719
Nevada			20,000		
Utah	1,562,098	2,209,428	1,135,330	1,147,570	2,184,708
Washington			39,785		
Wyoming					
Eastern States					
Southern States	296,463	467,448	732,793	2,374,514	3,105,036
Middle States					
Lead desilverizers and unapportioned	4,989,590	5,491,702	7,456,838	2,136,473	
	284,121,764	344,998,679	329,354,398	354,188,374	380,613,404

State.	1896	1897	1898	1899	1900
Arizona	72,934,927	81,530,735	111,158,246	133,054,860	118,317,764
California	690,237	11,987,772	16,925,634	26,221,897	28,511,225
Colorado [a]	6,022,176	11,873,033	16,274,561	11,643,608	7,826,949
Idaho		183,277	1,266,920	110,000	290,162
Michigan	143,524,069	145,282,059	158,491,703	147,400,338	145,461,498
Montana	221,918,179	232,728,479	207,434,550	225,143,875	270,753,636
New Mexico	2,701,664	701,892	1,592,371	3,935,441	4,169,400
Nevada			437,396	556,775	407,535
Utah	3,502,012	3,919,010	3,750,000	9,584,746	18,354,726
Wyoming			233,044	3,104,827	4,203,776
Eastern States					
Southern States	4,704,993	4,472,017	5,395,226	4,410,554	4,820,495
Middle States					
Lead desilverizers and unapportioned	4,063,173	[c] 1,400,000	3,553,336	[c] 3,500,000	[c] 3,000,000
	460,061,430	494,078,274	526,512,987	568,666,921	606,117,166

[a] For several of the early years the production credited to Colorado includes the yield from some ores of uncertain origin which were smelted in Colorado plants.
[b] Estimated.
[c] Based partly on estimates.

Copper produced in the United States, 1845–1915, in pounds—Continued.

State.	1901	1902	1903	1904	1905
Alaska			1,339,590	2,043,586	4,900,866
Arizona	130,778,611	119,944,944	147,648,271	191,602,958	226,854,461
California	33,667,456	25,038,724	17,776,756	28,529,023	16,697,489
Colorado	9,801,783	8,422,030	4,158,368	9,506,944	9,404,830
Idaho	480,511	227,500	778,906	2,158,858	7,321,585
Michigan	156,289,481	170,609,228	192,400,577	208,309,130	230,287,992
Montana	230,623,925	289,349,483	272,729,056	298,414,804	314,750,620
New Mexico	9,629,884	6,614,961	7,300,832	5,368,666	5,334,192
Nevada	593,608	164,301	150,000		413,292
Oregon					846,615
Utah	20,116,979	23,939,901	38,302,602	47,062,889	54,083,506
Washington		209,297	80,758	663,694	223,328
Wyoming	2,698,712	889,228	1,023,189	3,565,629	2,530,531
Eastern States					
Southern States	6,860,039	13,599,047	13,855,612	15,211,086	15,134,960
Middle States					
Lead desilverizers and unapportioned	531,530	500,000	500,000	100,000	
	602,072,519	659,508,644	698,044,517	812,537,267	888,784,267

State.	1906	1907	1908	1909	1910
Alaska	8,685,646	7,034,763	4,438,836	4,057,142	4,311,026
Arizona	262,566,103	256,778,437	289,523,267	291,110,298	297,250,538
California	28,153,202	33,696,602	39,643,835	53,568,708	45,760,200
Colorado	7,427,253	13,998,496	13,943,878	11,485,631	9,307,497
Idaho	8,578,046	9,707,299	7,256,086	7,096,132	6,877,515
Michigan	229,695,730	219,131,503	222,289,584	227,005,923	221,462,984
Montana	294,701,252	224,263,789	252,509,122	314,900,279	283,078,516
New Mexico	7,099,842	10,140,140	4,991,351	5,031,136	3,784,609
Nevada	1,090,635	1,998,164	12,241,372	53,849,281	64,494,640
Oregon	545,859	518,694	271,191	245,403	22,022
Utah	50,329,119	66,418,370	71,370,370	101,241,114	125,185,455
Washington	290,823	122,263	162,201	120,611	65,021
Wyoming	106,177	3,026,004	2,416,197	433,672	217,127
Eastern States and unapportioned	18,535,995	22,161,967	21,513,431	22,806,294	18,342,359
	917,805,682	868,996,491	942,570,721	1,092,951,624	1,080,159,509

State.	1911	1912	1913	1914	1915
Alaska	22,314,889	31,926,209	23,423,070	24,985,847	70,695,286
Arizona	303,202,532	359,322,096	404,278,809	382,449,922	432,467,690
California	35,835,651	31,516,471	32,492,265	29,784,173	37,658,444
Colorado	9,791,861	7,963,520	9,052,104	7,316,066	7,272,178
Idaho	4,514,116	7,182,185	8,711,490	5,875,205	6,217,728
Michigan	218,185,236	231,112,228	155,715,286	158,009,748	238,956,410
Montana	271,816,098	308,794,483	285,724,467	236,805,845	268,263,040
New Mexico	2,860,400	29,170,400	50,196,881	64,204,703	62,817,234
Nevada	65,561,015	83,413,900	85,209,536	60,122,904	67,757,322
Oregon	125,943	311,860	77,812	5,599	797,471
Utah	142,340,215	132,150,052	148,057,450	160,589,660	175,177,695
Washington	195,503	1,069,938	732,742	683,602	903,661
Wyoming	130,499	25,080	362,235	17,082	351,871
Eastern States and unapportioned	20,358,791	19,310,298	20,449,951	19,286,836	18,673,497
	1,097,232,749	1,243,268,720	1,224,484,098	1,150,137,192	1,388,009,527

The statistics from 1882 to 1910 are compiled from reports made by the producing companies to the United States Geological Survey. The statistics for individual States prior to 1882 have been compiled from the best sources available, and although they are not comparable with the later statistics in accuracy, they are believed to represent approximately the output of the individual States. Slight changes and readjustments in the former figures for Colorado, South Dakota, and Montana have been found desirable on comparison with figures

compiled by C. W. Henderson. The totals for the United States prior to 1882 are taken from compilations made in previous volumes of Mineral Resources.

Copper produced in the United States, 1845–1915.

State.	Quantity.	Percentage.	Rank.
	Pounds.		
Alaska	210,156,756	0.98	10
Arizona	5,072,851,628	23.73	3
California	612,421,961	2.87	5
Colorado	247,654,700	1.16	9
Idaho	87,058,408	.41	11
Michigan	5,759,983,236	26.93	2
Montana	6,703,097,139	31.32	1
New Mexico	301,572,781	1.41	8
Nevada	500,003,774	2.34	6
Oregon	3,768,469	.02	14
Utah	1,417,395,645	6.63	4
Washington	5,563,227	.03	13
Wyoming	26,730,167	.13	12
Eastern States and unapportioned	435,826,348	2.04	7
	21,384,084,239	100.00	.....

The totals in the preceding table show the copper output of each important copper-producing State, except those on the Atlantic coast, since the beginning of the industry. Some copper was produced in New Mexico in the early years of the last century, but the exact quantity is not known, though it was not large as measured by the present production of the metal. Prior to 1845 also a little copper was produced in Michigan and a considerable quantity in the Eastern States.

Under "Eastern States and unapportioned" is included some copper classed as "lead desilverizers" in the earlier reports of the Survey. This should properly be credited to some of the Western States. The output of the Central States, except Michigan, is also included under this head. Statistics for the individual Eastern States have not been compiled, but it may be stated that about 305,410,000 pounds has been derived from Tennessee. To the remainder Vermont and Virginia have made the largest contributions, and some copper has been produced by practically all the Appalachian States.

It will be noted that Montana, Michigan, and Arizona stand out as the three copper-producing States. Montana ranks first, with nearly one-third of the entire output of the country; Michigan ranks second, with more than one-fourth; and Arizona ranks third, with nearly one-fourth. Utah, ranking next in order, has produced about one-sixteenth of the total output. The three leading States have produced 82 per cent of the total.

It will be noted by reference to the table showing the output for 1915 that these three States still maintain their preeminence, having produced 81 per cent of the total output in 1908, 76 per cent in 1909, 74 per cent in 1910, 72 per cent in 1911 and 1912, 69 per cent in 1913, and 68 per cent in 1914 and 1915.

Mine production of copper in the principal districts in 1915, in pounds.

District or region.	State.	Approximate mine output.	Percentage of total production.	Rank.
Butte	Montana	267,000,000	17.94	1
Lake Superior	Michigan	238,956,000	16.06	2
Bingham	Utah	165,000,000	11.09	3
Bisbee	Arizona	164,600,000	11.06	4
Globe	do	98,500,000	6.62	5
Alaska (all districts)		70,695,000	4.75	6
Santa Rita	New Mexico	65,000,000	4.37	7
Ely	Nevada	64,638,000	4.34	8
Mineral Creek (Ray)	Arizona	60,338,000	4.05	9
Jerome	do	53,260,000	3.58	10
Morenci-Metcalf	do	51,096,000	3.43	11
Shasta County	California	30,500,000	2.05	12
Ducktown	Tennessee	18,205,000	1.22	13
Pioneer	Arizona	6,399,000	.43	14
Tintic	Utah	5,350,000	.36	15
Alder Creek	Idaho	4,700,000	.32	16
Big Bug	Arizona	4,285,000	.29	17
Lordsburg	New Mexico	3,890,000	.26	18
Cochise	Arizona	3,815,000	.26	19
Calaveras County	California	3,700,000	.25	20
Southwestern Colorado	Colorado	3,600,000	.24	21
Pima	Arizona	3,164,000	.21	22
Plumas County	California	3,000,000	.20	23
Ophir	Utah	2,212,000	.15	24
Courtland (Turquoise)	Arizona	2,048,000	.14	25
Placer County	California	1,900,000	.13	26
Cœur d'Alene	Idaho	1,900,000	.13	27
Uinta-Summit (Park City)	Utah	1,812,000	.12	28
Leadville	Colorado	1,800,000	.12	29
New Placers	New Mexico	1,700,000	.11	30
Goldfield	Nevada	1,670,000	.11	31
Burro Mountain	New Mexico	1,400,000	.09	32
Magdalena	do	1,400,000	.09	33
		1,407,533,000		
All others		80,467,000		
Grand total		1,488,000,000		

As shown in this table, 33 districts in 1915 each produced 1,000,000 or more pounds of blister copper.

In the following table the statistics for the later years are compiled from reports furnished to the United States Geological Survey by the producing companies, and those for the earlier years are taken mainly from reports on the several districts by members of the Survey.

Blister copper produced in the principal districts to the end of 1915.

District.	State.	Date production began.	Quantity (pounds).	Percentage of total production.	Rank.
Butte	Montana	1868	6,680,500,000	31.24	1
Lake Superior	Michigan	1845	5,759,983,236	26.93	2
Bisbee	Arizona	1880	2,025,860,000	9.47	3
Morenci-Metcalf	do	1873	1,221,296,000	5.71	4
Bingham	Utah	1896	1,149,500,000	5.37	5
Jerome	Arizona	1883	753,440,000	3.52	6
Globe	do	1881	683,200,000	3.20	7
Shasta County	California	1897	474,300,000	2.22	8
Ely	Nevada	1908	441,080,000	2.06	9
Ducktown	Tennessee	1850	305,410,000	1.43	10
Santa Rita	New Mexico	1800 (?)	298,911,000	1.40	11
Mineral Creek (Ray)	Arizona		219,978,000	1.03	12
Foothills Belt	California	1862	125,700,000	.59	13
Tintic	Utah	1880 (?)	124,500,000	.58	14

Fourteen districts in 8 States have each contributed in excess of 100,000,000 pounds to the copper output of the country. Five of these districts are in Arizona, 2 each in California and Utah, and 1 each in Montana, Michigan, Nevada, New Mexico, and Tennessee. Two districts stand out prominently. They are the Butte district, Mont., which has contributed nearly one-third of the output of the country, and the Lake Superior district, Mich., which has produced nearly 27 per cent of the total output. Bisbee, ranking third, has yielded 9.47 per cent of the total. The 14 districts have yielded about 95 per cent of the total output of the United States since 1845.

It is noteworthy that not a single one of the leading copper districts of the United States, several of which have been active producers for a period of 30 years or more, has been worked out or has showed a decrease in its ability to produce copper.

QUANTITY AND YIELD OF COPPER ORES.

COPPER-BEARING ORES PRODUCED.

The following tables show the quantity and the yield in copper of the ore produced by the mines of the United States in 1915. The figures are taken from the mines reports which form a part of the annual volume Mineral Resources. The close agreement between the output as reported by the mines and the actual recovery of metal as reported by the smelters indicates that the tenor of the ores as reported by the mines is very close to the actual recovery. The classification of some of the complex western ores is difficult and more or less arbitrary. Under copper ores are classed those which contain 2.5 per cent or more of copper, as well as those which contain less than this percentage, provided their principal value is in copper. Under copper-lead and copper-zinc ores are classed complex ores in which copper is a valuable constituent. Considerable copper was reported by the mines from ores mined primarily for other metals, including siliceous gold and silver ores, lead ores, zinc ores, pyritic sulphur ores, and ores concentrated for values in other metals. No attempt has been made to compile tables showing the quantity and yield of this group of copper-bearing ores, but together with old slags and other materials they have yielded a total of 33,311,494 pounds of copper.

Copper produced in 1915 from ores in which copper constitutes the principal value.

State.	Copper ore (short tons).	Copper in ore.		Gold in ore (fine ounces).	Silver in ore (fine ounces).	Value in gold and silver per ton.
		Quantity (pounds).	Percentage.			
Alaska	369,600	86,509,312	11.71	7,407.23	897,839	$1.65
Arizona	9,045,224	454,194,850	2.51	87,706.63	4,010,510	.42
California	601,815	40,751,625	3.39	23,797.60	1,056,895	1.71
Colorado	23,573	2,169,383	4.60	6,204.17	204,317	9.83
Idaho	74,901	5,510,427	3.68	3,997.33	171,931	2.27
Michigan	12,334,700	265,283,378	1.08	.....	585,933	.15
Missouri	186	19,460	5.23	.....	26	.07
Montana	4,803,398	256,259,789	2.67	30,840.90	8,819,772	1.05
Nevada	3,247,140	68,430,573	1.05	63,043.85	244,643	.44
New Mexico	2,552,609	76,153,386	1.49	18,221.02	513,288	.24
North Carolina	4,437	13,770	.16	763.39	160	.....
Oregon	3,722	451,172	6.06	83.01	9,807	1.80
Pennsylvania, Maryland, and Virginia	240,433	629,855	.13	25.83	.....	.....
Tennessee	623,534	18,046,010	1.45	331.95	100,543	.09
Texas	311	39,639	6.37	.....	3,797	6.19
Utah	9,436,450	177,915,329	.94	101,247.85	2,065,661	.33
Vermont	513	79,700	7.77	.....	353	.35
Washington	40,417	1,007,475	1.25	308.59	95,766	1.36
Wyoming	1,219	447,246	18.34	32.60	268	.66
Total and average	43,404,182	1,453,912,379	1.66	344,011.95	18,781,509	.38

Copper ores concentrated and smelted and copper produced from each class of ore in 1915.

State.	Ore concentrated.				Ore smelted.		
	Quantity.	Concentrates produced.	Copper in concentrates.	Percentage of copper from ore.	Quantity.	Copper produced.	Percentage of copper from ore.
	Short tons.	*Short tons.*	*Pounds.*		*Short tons.*	*Pounds.*	
Alaska	142,200	22,900	24,700,000	8.68	227,400	61,809,312	13.59
Arizona	6,486,923	482,268	187,637,795	1.44	2,558,301	266,557,055	5.21
California	.....	.....	.....	.....	[a]601,815	40,751,625	3.39
Colorado	.....	.....	.....	.....	23,573	2,169,383	4.60
Idaho	19,050	1,607	572,466	1.50	55,851	4,937,961	4.42
Michigan	12,334,700	200,089	265,283,378	1.08	.....	.....	.....
Missouri	.....	.....	.....	.....	186	19,460	5.23
Montana	4,227,468	1,472,961	188,818,296	2.23	575,930	67,441,493	5.86
Nevada	3,174,383	438,267	62,992,883	.99	72,757	5,437,690	3.74
New Mexico	2,382,626	159,672	66,309,429	1.39	169,983	9,843,957	2.90
North Carolina	.....	.....	.....	.....	4,437	13,770	.16
Oregon	3,722	.....	451,172	.....	.....	.....	.....
Pennsylvania, Maryland, and Virginia	240,361	8,205	602,111	.13	72	27,744	19.27
Tennessee	.....	.....	.....	.....	623,534	18,046,010	1.45
Texas	.....	.....	.....	.....	311	42,491	6.83
Utah	8,926,688	427,495	156,436,723	.84	509,762	21,478,606	2.11
Vermont	275	45	10,800	1.96	238	68,900	14.47
Washington	31,879	2,277	438,151	.69	8,538	569,324	3.33
Wyoming	.....	.....	.....	.....	1,219	447,246	18.34
Total and average	37,970,275	3,215,786	954,253,204	1.26	5,433,907	499,662,027	4.60

[a] Includes some ore concentrated.

Copper produced from copper-lead and copper-zinc ores in 1915.

State.	Copper-lead and copper-zinc ores.	Copper in ore.	Percentage of copper.
	Short tons.	*Pounds.*	
Arizona	426	45,502	5.34
Colorado	2,674	212,678	3.98
Idaho	2	464	11.60
Montana	215	22,838	5.31
Nevada	1,563	137,592	4.40
New Mexico	742	74,419	5.01
Utah	5,329	354,162	3.32
Total and average	10,951	847,655	3.87

Copper derived from ore classed as copper bearing (copper, copper-lead, and copper-zinc ores), and total production of copper from all sources in 1915.

State.	Ore treated.	Copper recovered.	Percentage of copper.	Copper from all sources, including old slags, smelter cleanings, and precipitates.
	Short tons.	*Pounds.*		*Pounds.*
Alaska	369,600	86,509,312	11.71	86,509,312
Arizona	9,045,650	454,240,352	2.51	[a] 459,972,295
California	601,815	40,751,625	3.39	40,751,625
Colorado	26,247	2,382,061	4.54	[b] 7,112,537
Idaho	74,903	5,510,891	3.68	6,978,713
Michigan	12,334,700	265,283,378	1.08	265,283,378
Missouri	186	19,460	5.23	[c] 402,160
Montana	4,803,613	256,282,627	2.67	[d] 267,231,014
Nevada	3,248,703	68,568,165	1.06	68,636,370
New Mexico	2,553,351	76,227,805	1.49	76,788,366
North Carolina	4,437	13,770	.16	[e] 17,170
Oregon	3,722	451,172	6.06	451,172
Pennsylvania, Maryland, and Virginia	240,433	629,855	.13	629,855
Tennessee	623,534	18,046,010	1.45	18,046,010
Texas	311	39,639	6.37	42,491
Utah	9,441,779	178,269,491	.94	[f] 187,671,188
Vermont	513	79,700	7.77	79,700
Washington	40,417	1,007,475	1.25	1,020,926
Wyoming	1,219	447,246	18.34	447,246
Total and average	43,415,133	1,454,760,034	1.68	1,488,071,528

[a] Considerable copper was recovered from old slags and ores not classed as copper ores.
[b] Most of the copper from Colorado is derived from ores classed as siliceous ores and lead ores.
[c] Mainly recovered in dressing lead ores.
[d] Considerable copper was recovered as precipitates from mine waters and from ores not classed as copper ores.
[e] From slag.
[f] A large quantity of copper was derived from ores classed as lead ores, lead-zinc ores, and siliceous ores.

Copper ores produced in the United States, 1906–1915, and average yield, copper, gold, and silver.

Year.	Copper ores.	Yield in copper.	Yield per ton in gold.	Yield per ton in silver.	Value per ton in gold and silver.
	Short tons.	*Per cent.*	*Ounces.*	*Ounces.*	
1906	18,000,000	2.50	0.0150	0.882	$0.856
1907	20,253,000	2.11	.0135	.609	.682
1908	22,290,886	2.07	.0104	.666	.560
1909	27,932,618	1.98	.0097	.655	.540
1910	28,497,238	1.88	.0093	.562	.495
1911	29,988,235	1.82	.0089	.555	.492
1912	35,656,414	1.71	.0073	.517	.468
1913	36,336,682	1.67	.0057	.502	.420
1914	35,175,541	1.60	.0075	.422	.39
1915	43,404,182	1.66	.0078	.428	.38

Copper ores produced in the United States, 1906–1915, classified as smelting and concentrating ores, and average yield in copper.

Year.	Smelting ores.		Concentrating ores.	
	Quantity.	Yield in copper.	Quantity.	Yield in copper.
	Short tons.	*Per cent.*	*Short tons.*	*Per cent*
1906	3,278,000	.....	14,722,000	.....
1907	3,957,500	4.05	16,295,500	1.41
1908	4,665,534	4.27	17,760,522	1.485
1909	5,267,707	4.15	22,664,911	1.47
1910	5,001,394	4.14	23,495,844	1.40
1911	4,355,650	4.66	25,632,585	1.34
1912	5,014,018	4.45	30,642,396	1.26
1913	5,290,310	4.22	31,046,372	1.22
1914	4,597,398	4.23	30,467,626	1.20
1915	5,433,907	4.60	37,966,553	1.26

The output of copper-bearing ores in 1915 showed a marked increase over that of any preceding year. For the last 10 years there has been a steady increase in the production of these ores except in 1914, when there was a slight decrease. During the 10 years the total output has increased about 140 per cent, the output of smelting ores has increased 40 per cent, and that of concentrating ores has increased 157 per cent. Michigan is the largest producer of copper ore, followed in order by Utah, Arizona, Montana, Nevada, New Mexico, Tennessee, California, and Alaska. In the output of smelting ore Arizona is first, followed by Tennessee, California, Montana, Utah, Alaska, and New Mexico. In the output of concentrating ore Michigan is first, followed by Utah, Arizona, Montana, Nevada, New Mexico, and Alaska.

YIELD OF COPPER FROM ORES.

The average yield of copper from copper ore in 1915 was 1.66 per cent. There was a steady decrease in the average yield of copper ores from about 2.50 per cent in 1906 to 1.60 per cent in 1914, but the yield for 1915 showed a slight increase.

The decrease in average yield may be taken as a general measure of the improvement in metallurgic practices which has made possible the profitable treatment of lower-grade material. The slight increase in 1915 is probably due in part to the selection of higher grades of ore in order to increase production and in part to increased recovery due to improvement in equipment, notably the addition of flotation equipment.

During the 10-year period 1906–1915 the average yield from direct smelting ores has shown an increase from about 4.05 per cent to 4.60 per cent; that of concentrating ores decreased from 1.48 per cent in 1908 to 1.20 per cent in 1914, but the yield for 1915 was 1.26 per cent.

Of the important copper-producing States Alaska produced the highest grade of copper ore in 1915, followed in order by California, Montana, Arizona, New Mexico, Tennessee, Michigan, Nevada, and Utah. Of the States producing large amounts of smelting ore, Alaska had the highest yield, followed by Montana, Arizona, California, New Mexico, and Tennessee. Of the States producing large amounts of

concentrating ore, Montana had the highest grade, followed by Arizona, New Mexico, Michigan, Nevada, and Utah.

The average recovery of gold and silver from copper ores shows a decrease about in proportion to the decrease in copper. In 1906 copper ores averaged 85.6 cents per ton in gold and silver; in 1915 the average yield was 38 cents per ton. Among the principal copper-producing States Alaska was first in the average yield of gold and silver per ton of ore, followed by California, Montana, Nevada, Arizona, Utah, and New Mexico.

REVIEW BY STATES.

SCOPE OF DISCUSSION.

In the following pages a brief statement of the conditions affecting production in the principal copper districts of the country is presented, the geologic occurrence of the ores is briefly summarized, and the tenor of ore from each district is given so far as it does not disclose the production of individual companies the figures of whose output have not already been published in their annual reports or elsewhere. Those who desire more detailed information on the mining operations of the districts are referred to the reports on mine production for the several States, which form other chapters of Mineral Resources, as shown in the prefatory note.

Figures of metal output, ore reserves, metal content, and recovery in treatment of individual companies given in this report, unless otherwise stated, are quoted from the official reports of the companies.

The accompany map (Pl. I, in pocket) shows the location of the districts that have contributed in any notable degree to the output of copper during the last three years. Unfortunately, this limitation in time excludes some districts which contain valuable copper deposits, but which were not producers during the period covered, and, on the other hand, it includes districts that will probably never be of great importance and yet have produced considerable copper during the specified period. The symbols showing the relative output of the principal camps from the beginning of production must not be interpreted as representing the present relative importance of the several districts or as in any way representing the possibilities. Several districts that show very poorly on total relative output are now important contributors, and still others whose relative output is not represented will be important producers in a short time. Past production is not necessarily a measure of future output for either a mine or a district. The figures on which the symbols showing relative output are based will be found in the table (p. 667), showing the production of the principal districts and in the descriptions of the individual districts. The present relative importance of the several districts can be ascertained by consulting the table showing the output of the principal districts for 1915. The list of reduction plants accompanying the map includes all copper smelters and refineries operated during the three years, and it also includes copper-smelting plants in process of construction during 1915 and others that were not operated in 1915, but are likely to be reopened.

ALASKA.

The production of blister copper from Alaska in 1915 was 70,697,286 pounds, as compared with 24,985,847 pounds in 1914. The mine production of copper for 1915 was 86,509,312 pounds.

Alaska began to produce copper in notable quantity about 1903, and since that time it has been a steady contributor. Its total production of blister copper to the end of 1915 has been 210,158,756 pounds. The output for 1915 came from the Ketchikan, Prince William Sound, and Copper River districts.

Ketchikan district.—Copper mining in the Ketchikan district was unusually active in 1915. The mines yielded 50,406 tons of ore, from which 1,728,182 pounds of copper were produced. The deposits of the district[1] thus far developed are of contact origin. The ores run high in iron, being composed of chalcopyrite, pyrrhotite, magnetite, and pyrite, and are desirable ores for the British Columbia and Washington smelters. They are shipped to the smelter at Tacoma.

Prince William Sound district.—Copper mining in the Prince William Sound district was active, and the output was one of the largest made by this district. The ores of the district were shipped to the Tacoma smelter. The developed deposits[2] consist of pyrrhotite, chalcopyrite, and pyrite, with minor quantities of other sulphides, occurring chiefly in shear zones in sedimentary rocks and to a less extent in greenstone. The largest producer was the Beatson Bonanza mine, but considerable ore was taken from the Ellamar mine. Other copper properties were being developed, and made small production.

The Beatson mine is equipped with a 700-ton concentrator employing the oil flotation process. For the period May 27 to December 31 the ore milled contained an average of 2.23 per cent copper. The average recovery was 77.17 per cent. Concentrates averaged 15.87 per cent copper.

Copper River district.—The Bonanza and Jumbo mines of the Kennicott Copper Corporation were the largest producers in the Copper River district. The Mother Lode Copper Mines Co., of the Chitina district, also produced in 1915.

The primary ores[3] of the Bonanza and Jumbo mines are principally chalcocite, with some bornite, replacing limestone near a greenstone contact. These minerals have been slightly altered to carbonates at the surface. This is one of the few important copper deposits known in which chalcocite, the principal ore mineral, has generally been regarded as a primary mineral, though there is some question whether it may not have resulted from solutions enriching bornite. The mines are equipped with a 700-ton concentrator. The ore treated during the period May 27 to December 31 averaged 10.2 per cent copper.

[1] For detailed descriptions, see Wright, C. W., and Paige, Sidney, Mineral resources of Alaska in 1907: U. S. Geol. Survey Bull. 345, pp. 98–115, 1908; Wright, F. E., and Wright, C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, 1908; and Smith, P. S., Lode mining in the Ketchikan region, Alaska: U. S. Geol. Survey Bull. 592, pp. 75–94, 1914; Wright, C. W., Geology and ore deposits of Copper Mountain and Kasaan Peninsula, Alaska: U. S. Geol. Survey Prof. Paper 87, 1915.

[2] Grant, U. S., and Higgins, D. F., Reconnaissance of the geology and mineral resources of Prince William Sound, Alaska: U. S. Geol. Survey Bull. 443, pp. 87–96, 1910. Capps, S. R., and Johnson, B. L., Mineral deposits of the Ellamar district: U. S. Geol. Survey Bull. 542, pp. 86–124, 1912. Lincoln, F. C., The Big Bonanza copper mine, Latouche Island, Alaska: Econ. Geology, vol. 4, pp. 201–213, 1909. Thompson, A. P., On the relation of pyrrhotite to chalcopyrite and other sulphides: Econ. Geology, vol. 9, pp. 171–173, 1914.

[3] Moffit, F. H., and Maddren, A. G., Mineral resources of the Kotsina-Chitina region, Alaska: U. S. Geol. Survey Bull. 374, 1909. Moffit, F. H., and Capps, S. R., Geology and mineral resources of the Nizina district, Alaska: U. S. Geol. Survey Bull. 448, 1911. Tolman, C. F., jr., Observations on certain types of chalcocite and their characteristic etch patterns: Am. Inst. Min. Eng. Bull. 110, p. 401, 1916.

The average recovery was 84.67 per cent. The concentrates averaged 54.1 per cent copper. An ammonia leaching plant is under construction to treat tailings from the concentrator.

The mines of the Kennicott Copper Corporation in Alaska produced approximately 63,000,000 pounds of copper during the last seven months of the year. The cost per pound of the copper smelted during this period was 4.54 cents. The value of silver per pound of copper was 0.52 cent.

ARIZONA.

In 1915 Arizona produced 432,467,690 pounds of blister copper, compared with 382,449,922 pounds in 1914.

The steady output of copper from Arizona began about 1875, though there had been intermittent production since 1862. Since 1880 the growth of the industry has been steady and rapid, and to the end of 1915 Arizona had a recorded production of 5,072,851,628 pounds of copper, or 23.73 per cent of the total output of the country, thus ranking third among the States. In 1915 Arizona produced 31.16 per cent of the total output. The greater part of the production came from five districts. Nine copper-smelting plants were operated within the State during the year.

Bisbee district.—The Bisbee or Warren district, in southern Cochise County, was the largest producer in the State in 1915, as in previous years. Production in this district began in 1880, and since that time it has been a constant and increasingly important contributor to the output of copper. To the end of 1915 it had produced 2,025,860,000 pounds of copper, or 9.47 per cent of the output of the country. In total output it ranks third and in present output fourth among the copper districts of the country.

Copper produced in Bisbee district, Ariz., 1906–1915.

Year.	Quantity.	Average yield in copper.	Value in gold and silver per ton.	Year.	Quantity.	Average yield in copper.	Value in gold and silver per ton.
	Pounds.	*Per cent.*			*Pounds.*	*Per cent.*	
1906	131,000,000	6+	.....	1911	130,200,000	5.9	$1.42
1907	110,000,000	6+	.....	1912	140,000,000	5.6	1.41
1908	129,000,000	6+	.....	1913	155,100,000	5.6	1.16
1909	130,000,000	6+	.....	1914	151,600,000	5.4	1.35
1910	142,500,000	5.4	$1.07	1915	164,600,000	5.0	1.66

The oldest rocks[1] in the Bisbee district, according to Ransome, are the pre-Cambrian Pinal schist, which has been intruded by granite, probably also of pre-Cambrian age. On this basement were deposited more than 5,000 feet of paleozoic sediments, consisting for the most

[1] For detailed geologic reports see Ransome, F. L., Geology and ore deposits of the Bisbee quadrangle, Ariz.: U. S. Geol. Survey Prof. Paper 21, 1904. Rice, C. T., Camp of Bisbee, Ariz.: Mines and Methods, Salt Lake City, Utah, vol. 1, p. 241, 1909. Douglas, James, Notman, Arthur, Legrand, Charles, and Lee, G. B.., The Copper Queen mines and works, Arizona, U. S. A.: Inst. Min. and Met. Trans., vol. 21, pp. 532–590, 1913; Eng. and Min. Jour., Mar. 8, 1913. Ransome, F. L., Notes on the Bisbee district, Ariz.: U. S. Geol. Survey Bull. 529, pp. 179–182, 1913. Tenney, J. B., Bisbee porphyry deposits: Eng. and Min. Jour., vol. 97, p. 467, 1914. Vail, R. H., The Copper Queen smelting works: Eng. and Min. Jour., vol. 99, pp. 1–6, 1915. Bonillas, Y. S., Tenney, J. B., and Feuchére, Leon, Geology of the Warren district: Am. Inst. Min. Eng. Bull. 117, pp. 1397–1466, 1916. Wilson, P. D., Stoping in the Calumet & Arizona mines, Bisoee, Ariz.: Am. Inst. Min. Eng. Bull. 117, pp. 1100–1117, 1916.

part of limestone, with quartzite at the base. These beds were intruded in early Mesozoic time by stocks, dikes, and sills of granite porphyry. After a period of erosion Cretaceous sediments were deposited on the earlier formations, but these have since been largely removed from the producing area.

The primary ores were deposited during and after the intrusion of the granite porphyry and were genetically connected with that intrusion. The presence of garnet, tremolite, diopside, and other silicates associated with the ore minerals indicates a contact-metamorphic origin of the deposits in the limestone.

The principal ore bodies in the sedimentary rocks occur around the porphyry stock of Sacramento Hill and along faults and fissures where the ore minerals have replaced the limestone. The principal ore bodies thus far developed have been in the Carboniferous and Devonian limestones, but in recent years valuable deposits have been discovered in the Cambrian limestone and also in the granite porphyry stock.

In the northern part of the district the ore deposits in the sedimentary rocks are in many places closely associated with porphyry bodies, and this association serves to some extent as a guide in prospecting, but in the south end of the district porphyry intrusions are less abundant and the ore bodies are associated with fissures.

The primary ores consist mainly of pyrite, chalcopyrite, and bornite, with smaller bodies of galena and some sphalerite. Alteration by surface solutions has extended to great depth, and a large part of the ore extracted has been oxidized and enriched sluphide. In recent years, however, large bodies of primary sulphides of commercial grade have been developed. Most of the ore occurs in irregular bodies without any definite arrangement, and the cost of prospecting is consequently rather high. The irregular character of the ore deposits and the heavy ground, especially in the oxidized ore bodies, have resulted in relatively high cost of extraction. Recently, however, modifications in the system of mining have resulted in a decrease in the amount of timber used per ton of ore and also in the cost of extraction. The cost of mining will, nevertheless, doubtless remain high compared with the cost in districts where cheaper systems of mining can be safely and economically employed.

In recent years large bodies of disseminated ore have been found in the altered granite porphyry of Sacramento Hill. The ore, according to J. B. Tenney, consists of chalcocite, some bornite and chalcopyrite, and considerable pyrite in a siliceous gangue.

Developments during the year resulted in an increase in the ore reserves of the district over those of the previous year.

The production of the Copper Queen Consolidated Mining Co., as summarized in the company's report, is as follows:

Metals produced by Copper Queen Consolidated Mining Co., 1915.

	Ore, dry weight.	Gold.	Silver.	Copper.	Lead.
	Short tons.	*Ounces.*	*Ounces.*	*Pounds.*	*Pounds.*
Shipped to Douglas:					
Ore	739,116	17,643	721,726	83,589,550	.....
Ore from lessees	9,956	220	8,190	1,134,501	.....
Shipped to Globe:					
Sulphide ore	2,165	66	975	62,459	.....
Shipped to El Paso:					
Sulphide ore	516	39	1,510	76,866	.....
Silver Lead Ore Co.	22,899	913	192,025	872,107	8,748,615
Silver-lead ore from lessees	239	33	1,024	2,115	63,036
Delivered to experimental concentrator:					
Copper ore	4,407	.....	.....	.....	.....
Lead ore	3,913	.....	.....	.....	.....
Miscellaneous:					
Precipitates	601	.....	28	383,899	.....
Old dump slag	46,965	.....	4,309	2,191,925	.....
Concentrates shipped:					
Copper to Douglas	1,359	17	621	223,317	.....
Lead to El Paso	971	43	12,960	14,441	576,767
	833,107	18,974	943,368	88,551,180	9,388,418

Metals produced by Copper Queen Consolidated Mining Co., 1911–1915.

Year.	Ore.	Copper.	Silver.	Gold.	Lead.	Earnings.	Dividends.
	Short tons.	*Pounds.*	*Ounces.*	*Ounces.*	*Pounds.*		
1911	619,132	74,489,728	1,227,453	16,895	5,658,930	$4,155,010	$5,200,000
1912	786,368	88,280,908	1,027,130	18,023	2,953,685	6,977,378	5,707,351
1913	867,481	97,181,725	919,138	16,213	5,701,628	6,916,900	5,700,000
1914	732,829	86,066,143	1,036,672	15,769	8,889,175	6,042,001	4,500,000
1915	833,107	88,551,180	943,368	18,974	9,388,418	.....	.....

The company reports at the end of 1915 limestone mine reserves of 2,951,852 tons, including 254,912 tons of lean sulphides. This is a slight decrease from the reserves reported a year before. Sacramento Hill (disseminated) reserves, at a 1.3 per cent minimum, are reported as 8,542,836 tons, averaging 2.732 per cent copper. At a 1 per cent minimum, the reserves were 11,633,481 tons, averaging 2.455 per cent copper. Experimental tests on concentration of the Sacramento Hill ores gave a recovery of 85.45 per cent on ores averaging 2.96 per cent copper, with a concentrate averaging 8.22 per cent copper.

The reduction plant at Douglas treated 1,287,294 tons of ores and concentrates, yielding 125,144,024 pounds of copper, 1,388,149 ounces of silver, and 28,840 ounces of gold. The loss of copper in smelting amounted to 6.50 per cent.

Metals produced by Calumet & Arizona Mining Co., including the Superior & Pittsburgh Co., before the consolidation of the two, 1911–1915.

Year.	Company.	Ore smelted.	Copper produced.	Copper recovered.	Gold.	Silver.	Dividends.
		Short tons.	*Pounds.*	*Per cent.*	*Ounces.*	*Ounces.*	
1911	Calumet & Arizona	231,135	21,476,739	4.487	9,329	216,987	$1,989,059
	Superior & Pittsburgh	230,620	28,469,166	6.1859	8,785	236,960	1,739,758
1912	Calumet & Arizona	169,287	16,490,229	4.34	9,066	233,092	2,542,781
	Superior & Pittsburgh	318,418	36,618,399	5.762	13,815	361,227	1,919,733
1913	Calumet & Arizona	111,541	52,621,651	4.485	15,890	540,214	3,059,208
	Superior & Pittsburgh	376,568		5.785			
1914	Calumet & Arizona	540,468	49,992,909	4.62	19,744	573,606	1,851,008
1915	do	729,677	63,126,931	4.33	26,212	947,129	2,006,557

At the reduction works at Douglas a total of 823,402 tons of ore was treated. The company reported an increase in ore reserves during 1915 of 366,551 tons.

Metals produced by Shattuck Arizona Copper Co., 1911–1915.

Year.	Copper.	Silver.	Gold.	Lead.	Copper recovered.	Dividends.
	Pounds.	*Ounces.*	*Ounces.*	*Pounds.*	*Per cent.*	
1911 [a]	4,111,000					
1912 [b]	1,253,305	21,008	13		7.13	
1912 [c]	1,746,493	15,165	16		6.67	
1913	13,219,756	236,000	2,033	1,483,956	6.67	$525,000
1914	10,846,918	198,419	2,445	14,065	5.79	525,000
1915	11,154,211	201,869	3,151	2,345,342	5.89	875,000

[a] Year ending August, 1911.
[b] Year ending August, 1912.
[c] Aug. 1 to Dec. 31, 1912, inclusive.

Mine and smelter production of Shattuck Arizona Copper Co., 1915.

		Copper ore.		Lead ore.	
		Wet.	Dry.	Wet.	Dry.
Ore mined	tons	107,029	95,570	8,615	8,238
Ore shipped	do	105,444	94,041	8,582	8,199
Ore smelted	do	105,952	94,591	8,169	7,800
Bullion recovered	per cent		5.896		15.034
Copper recovered	pounds		11,154,211		
Gold recovered	ounces		3,151		
Silver recovered	do		201,869		
Lead recovered	pounds		2,345,342		
Net cost per pound of refined copper	cents		8.446		

Globe district.—Production of copper began in the Globe district in 1881; the camp was well known as a silver producer before that date. For several years the production was intermittent, but since 1888, and especially since 1898, when the railroad reached the camp, the district has ranked among the important copper producers of the country. To the end of 1915 it has produced 683,200,000 pounds of copper, or 3.2 per cent of the output of the country since 1845. In total production the district ranks seventh in the country and fourth in the State; for 1915 it ranked fifth in the country and second in the State. The Miami part of the district made its first notable output in 1911 and will continue to grow in importance.

Copper produced in Globe district, Ariz., 1906–1915.

Year.	Copper.	Yield of ore in copper.	Year.	Copper.	Yield of ore in copper.
	Pounds.	*Per cent.*		*Pounds.*	*Per cent.*
1906	27,000,000	3.4	1911	44,600,000	3.35
1907	35,000,000	4	1912	61,600,000	2.21
1908	36,000,000	4.5	1913	71,000,000	2.38
1909	33,000,000	4.43	1914	72,000,000	2.41
1910	27,600,000	5	1915	98,500,000	2

The geology [1] of the district may be briefly summarized as follows. Paleozoic sediments, consisting of conglomerates, quartzites, shales, and limestones, were laid down unconformably on a pre-Cambrian basement of schist and intruded granitic rocks. In post-Paleozoic time the region was invaded by diabase followed by granitic rock. After a period of erosion the area was partly or wholly buried beneath Tertiary volcanic and sedimentary rocks, which have since been partly removed by erosion.

The copper deposits are believed to have been introduced at the time of or soon after the post-Paleozoic granitic intrusion and the source of the copper-bearing solutions is believed to have been connected with this intrusion. The deposits of the district are of very different types, their character depending largely on the nature of the rocks in which they were formed. In the Globe end of the district the deposits occur as roughly lenticular bodies replacing limestone, and as fault lodes or fissure zones of quartz and sulphide in diabase. In the Miami end of the district the ores occur mainly as small veins of quartz and sulphide in the shattered rock near the granite and schist contact, the mineralization having affected both formations.

In the Globe area most of the ores so far developed owe their commercial value to enrichment. The ore extracted from the limestone has been largely oxidized, and much of the ore developed in the diabase has been enriched sulphide. Under favorable conditions the enrichment has gone on to the greatest depth to which the workings have extended. Some bodies of primary ore of commercial grade have also been developed.

In the disseminated bodies of the Miami area the original ore consisted of sulphides of iron and copper. The copper content of the ores near the surface has been partly taken into solution and redeposited as chalcocite on the sulphides lower down. The ore consists of grains of pyrite and chalcopyrite partly or wholly replaced by chalcocite. The bodies of ore are blanket-like deposits overlain by leached "capping" and underlain by primary material too lean in copper to be classed as ore.

In places the sulphide ore is overlain by a considerable quantity of oxidized and partly oxidized ore of a grade that will permit extraction when a satisfactory method of recovering the metal is devised.

An exceptional type of ore is that of the Black Warrior mine, which is oxidized ore cementing dacite tuff or breccia.

The ores in the Globe area vary greatly in copper content, the grade to be mined at any given time depending largely on the possibility of profitable treatment. In general ores of as low grade as can be handled with reasonable profit are mined. During 1915 the ores of the entire district yielded about 2 per cent of copper and about 9 cents per ton in gold and silver. The mines of the district produced 2,384,000 tons of concentrating ore, yielding an average of 1.62 per cent of copper, and 183,800 tons of smelting ore, yielding an average of 7 per cent of copper.

[1] For detailed description, see Ransome, F. L., Geology of the Globe copper district, Ariz.: U. S. Geol. Survey Prof. Paper 12, 1903; Geology at Globe, Ariz.; Min. and Sci. Press, vol. 100, p. 256, 1910; Geology of the Globe district, Ariz.; idem, vol. 102, p. 747, 1911. Tolman, C. F., jr., Min. and Sci. Press, vol. 99, p. 646, 1909. Higgins, Edwin, Eng. and Min. Jour., vol. 89, pp. 769, 813, 870, 1910. Ransome, F. L., U. S. Geol. Survey Bull. 529, pp. 183–186, 1913. Tovote, W. L., Globe mining district, Ariz.; Min. and Sci. Press, vol. 108, pp. 442 and 487–492, 1914.

The smelter of the Old Dominion Co. was operated throughout the year, and the new plant of the International Smelting & Refining Co.[1] at Miami was blown in May 8, 1915, and operated continuously for the remainder of the year.

The district is served by the Arizona Eastern Railroad.

Metals produced by Old Dominion Copper Mining & Smelting Co., 1911–1915.

Year.	Ore.	Copper.	Gold.	Silver.	Average yield in copper.	Cost per pound of copper.	Dividends.
	Short tons.	*Pounds.*	*Ounces.*	*Ounces.*	*Per cent.*	*Cents.*	
1911	174,246	19,195,181	936	42,050	5.84	9.5	$486,000
1912	201,181	16,533,993	583	42,750	4.67	10.34	729,000
1913	169,961	18,945,153	419	51,316	5.88	9.7	810,000
1914	129,813	17,816,284	603	33,311	7.44	8.22	445,500
1915	115,459	13,771,681	620	40,632	6.56	8.90	1,053,000

In the foregoing table the relation of cost per pound of copper and copper content of ore is strikingly evident. Dividends paid by the Old Dominion Co. to December 31, 1915, amount to $6,480,000.

Ore produced by Old Dominion Copper Mining & Smelting Co., 1915.

	Quantity (short tons).	Percentage of copper.
Smelting ore	80,512	7.81
Concentrating ore	32,380	3.72
Silica ore	2,567	3.65
	115,459	6.56

Large bodies of concentrating ore were developed in the west end of the mine on the seventeenth and eighteenth levels. Mining operations were suspended for five weeks in the spring and were seriously hindered for a much longer period by an unusually large flow of water that is attributed to the heavy rainfall in the later part of 1914 and the early part of 1915.

Metals produced by United Globe mines, 1911–1915.

Year.	Ore.	Copper.	Silver.	Gold.	Yield in copper.	Dividends.
	Short tons.	*Pounds.*	*Ounces.*	*Ounces.*	*Per cent.*	
1911	110,578	8,525,433	111,459	876	3.85	.....
1912	188,254	12,252,073	124,362	789	3.25	$460,000
1913	167,919	11,348,100	119,588	1,537	3.38	690,000
1914	155,205	11,086,674	91,582	1,580	3.57	425,500
1915	141,240	11,536,021	105,109	1,508	4.08	621,000

[1] Kerns, R. W., International smelter at Miami: Eng. and Min. Jour., vol. 101, pp. 421–424, 1916.

Dividends paid by the United Globe mines from January, 1904, to December, 1914, amounted to $2,576,000.

Ore produced by United Globe mines, 1915.

	Quantity (short tons).	Percentage of copper.
Smelting oxide	19,112.048	6.90
Smelting sulphide	291.556	1.01
Concentrating ore	119,537.028	3.63
Silica converter lining	2,299.517	4.73
	141,240.149	4.08

The Arizona Commercial Mining Co. produced 44,353 tons of ore averaging 4.872 per cent copper. The metal output was 3,592,274 pounds of copper, 16,511 ounces of silver, and 282 ounces of gold. The net earnings for the year were $211,775.

Copper produced by Miami Copper Co., 1911–1915.

Year.	Ore.	Copper content.	Mill extraction.	Refined copper.	Cost of copper per pound.	Dividends.
	Short tons.	*Per cent.*	*Per cent.*	*Pounds.*	*Cents.*	
1911	445,036	2.48	73.37	15,385,783	9.103	.....
1912	1,040,744	2.393	69.39	32,832,609	9.5884	$1,100,112
1913	1,058,784	2.30	71.06	32,867,666	10.6086	1,491,989
1914	1,096,633	2.28	69.93	33,296,010	9.2045	1,120,375
1915	1,348,122	2.17	75.17	41,832,059	8.76	1,681,004

Milling operations of Miami Copper Co., 1915.

Ore milled	short tons	1,348,122
Copper in ore	per cent	2.17
Concentrates produced	short tons	52,539
Copper in concentrates	per cent	41.91
Copper in concentrates	pounds	44,033,761
Copper recovered per ton of ore	do	32.66
Mill extraction	per cent	75.17

Cost of copper in concentrates f. o. b. cars at Miami, Ariz., 1915.

	Per ton of ore.	Per pound of copper.
Mining	$1.0158	$0.032736
Milling	.5794	.018672
General	.2833	.009130
	1.8785	.060538

Ore reserves of Miami Copper Co., Jan. 1, 1916.

	Quantity (short tons).	Percentage of copper.
High-grade sulphide ore	18,140,000	2.40
Low-grade sulphide ore	17,000,000	1.21
	35,140,000	1.82

The first unit of the Inspiration mill,[1] owned by the Inspiration Consolidated Copper Co., went into operation June 29, 1915. At the end of the year 12 units were in operation, and in February, 1916, all 18 units were in operation. In the first half of March, 1916, the mill treated an average of 13,600 tons of ore a day. The production of copper for the period July to December, 1915, inclusive, was 20,445,670 pounds. The amount of ore treated was 778,851 tons. The recovery was as follows:

Recovery of copper at mill of Inspiration Consolidated Copper Co., 1915.

	Per cent.
Assay of ore milled	1.702
Oxide copper in ore	.226
Assay of tailings	.373
Oxide copper in tailings	.18
Assay of concentrates from flotation	37.63
Assay of concentrates from tables	13.12
Average assay of concentrates—total made	32.67
Average recovery of total copper in ores milled	79.95
Average recovery on sulphide copper in ores milled	88.56

The average cost per pound of copper was 8.136 cents, apportioned as follows:

Cost of copper derived from concentrating ores of Inspiration Consolidated Copper Co., 1915.

	Cost per pound of copper.	Cost per ton of ore.
Mining	$0.02644	$0.68110
Coarse crushing	.00113	.02910
Ore hauling	.00079	.02025
Concentrating and royalty	.01889	.48675
Concentrate hauling	.00006	.00160
Smelting, freight, refining, marketing, etc	.03455	.7642
	.08136	1.9830

The estimated tonnage of ore is reported the same as for 1914.

Ore resources of Inspiration Consolidated Copper Co., Dec. 31, 1915.

Material.	Developed in original exploration.		Developed by drilling in 1913.		Originally developed but not reported.		Keystone ore through purchase of property, 1914.		Total.	
	Quantity (short tons).	Percentage of copper.	Quantity (short tons).	Percentage of copper.	Quantity (short tons).	Percentage of copper.	Quantity (short tons).	Percentage of copper.	Quantity (short tons).	Percentage of copper.
Sulphide ore	45,000,000	2					1,252,000	2.24	46,252,000	2.01
Low sulphide material			2,839,000	1.45	25,483,000	1.24	376,000	1.13	28,698,000	1.26
Oxidized material			3,767,000	1.33	8,678,000	1.34	5,015,300	1.25	17,460,300	1.31
Mixed carbonate and sulphide material			252,000	1.53	3,624,000	1.22	856,700	1.62	4,732,700	1.31
	45,000,000	2	6,858,000	1.39	37,785,000	1.26	7,500,000	1.45	97,143,000	1.63

[1] Burch, H. K., Mine and mill plant of the Inspiration Consolidated Copper Co.: Am. Inst. Min. Eng. Bull. 117, pp. 1467–1500, 1916.

The Black Warrior and other mines made notable production in 1915.

Morenci-Metcalf district.—The Morenci-Metcalf district is one of the oldest copper-producing districts in the State, the output beginning as early as 1873, and since 1880 it has been a large contributor to the copper output of the country. To the end of 1915 it had produced 1,221,296,000 pounds of copper, or 5.71 per cent of the output of the country since 1845. In total production it ranks fourth among the copper districts of the country. In the output for 1915 it ranks eleventh.

Copper produced in Clifton-Morenci district, Ariz., 1906–1915.

Year.	Quantity.	Average yield of copper from ore.	Year.	Quantity.	Average yield of copper from ore.
	Pounds.	*Per cent.*		*Pounds.*	*Per cent.*
1906	56,000,000	.....	1911	71,500,000	2.29
1907	63,000,000	.....	1912	79,900,000	2.21
1908	77,000,000	.....	1913	70,100,000	2.00
1909	72,000,000	2.29	1914	66,000,000	1.95
1910	73,154,000	2.35	1915	51,096,000	2.01

The decrease in the production for 1915 was due in part to curtailment in the first months of the year on account of market conditions, but principally to a strike of the miners of the district, which resulted in the closing of the mines and smelters of the three principal producing companies from September 11, 1915, to February, 1916.

The copper ores [1] of this district occur as contact deposits in Paleozoic limestones and shales which have been intruded by stocks and dikes of porphyry, as disseminated deposits mainly in the porphyry, and as deposits in fault fissures of the Coronado type.

The origianl ores were pyrite and chalcopyrite of too low grade to be of economic importance. The workable bodies have resulted from the process of enrichment. The ore bodies in the limestone were formed in certain beds favorable to deposition, and this produced roughly tabular bodies nearly parallel to the stratification of the limestone. Alteration of these bodies has produced oxidized ores, which formed most of the workable ores in the limestone. These are now nearly exhausted.

The disseminated ores occur in highly altered porphyry adjacent to fissure veins. The copper content of the upper parts of these deposits has been leached and deposited as chalcocite on the pyrite lower down. This has produced a zone of ore varying in thickness, but in general not extending below a depth of 400 feet.

In the fault-fissure or Coronado type of deposit ore has been developed to much greater depth, and in Copper Mountain ore also occurs associated with the principal faults considerably below the general level of the ore zone.

In 1915 of the mine production of copper 41,846,589 pounds was derived from concentrating ores and 8,287,984 pounds from smelting ores. The mines of the district produced 1,150,018 tons of concen-

[1] For detailed report see Lindgren, Waldemar, The copper deposits of the Clifton-Morenci district, Ariz.: U. S. Geol. Survey Prof. Paper 43, 1905. Tovote, W. L., Min. and Sci. Press, vol. 101, p. 770, 1910.

trating ores, yielding an average of 1.82 per cent copper, and 112,864 tons of smelting ore, yielding an average of 3.67 per cent copper; the average yield for the 1,262,882 tons of ore produced in the district was 1.98 per cent.

The ores in general carry little gold and silver, and, as much of the copper is of sufficient purity for commercial purposes, it is not refined electrolytically, and consequently the precious-metal content is not separated from the copper.

Modified systems of slicing and caving are now very largely employed in the extraction of ore, and the timber required has thus been very materially reduced from the amount required by the square-set method.

Copper produced by Detroit Copper Co., 1911–1915.

Year.	Ore treated (short tons).	Copper produced.		Dividends.
		Quantity (pounds).	Percentage.	
1911	517,087	22,704,398	2.29	$800,000
1912	520,272	24,802,789	2.38	1,464,610
1913	537,324	22,255,130	2.07	780,000
1914	477,581	20,272,607	2.12	280,000
1915	376,604	15,333,976	2.03	.....

Copper produced by Detroit Copper Co., 1915, by kinds of ore.

	Ore treated.	Copper produced.	Assay of original ore.	Yield per ton.
	Short tons.	*Pounds.*	*Per cent.*	*Per cent.*
Concentrating ore	363,966	13,633,650	2.69	1.873
Smelting ore	4,563	861,361	9.88	9.44
Old slag and tailings	1,780	130,459	4.06	3.66
Siliceous ore to converters	6,295	708,506	5.84	5.62
	376,604	15,333,976	2.83	2.036

Result of smelting and converting operations of Detroit Copper Co., 1915.

Ore, concentrates and flux smelted	short tons	77,870.3
New copper-bearing material smelted	do	66,437.0
Copper contained to account for	do	8,156.39
Copper in bullion produced	do	7,666.988
Metallurgic loss	do	489.402
Loss in slag	do	141.542
Unaccounted for	do	347.860
Recovery	per cent	94.00
Copper in matte	do	35.21
Copper in slag	do	.28
Coke in total charge	do	11.95
Limestone in total charge	do	10.36

Copper produced by Arizona Copper Co., 1911–1915.

Year ending Sept. 30.	Ore treated.	Copper produced.	Average yield.	Year ending Sept. 30.	Ore treated.	Copper produced.	Average yield.
	Short tons.	*Pounds.*	*Per cent.*		*Short tons.*	*Pounds.*	*Per cent.*
1911	744,746	34,584,000	2.32	1914	1,079,950	38,756,000	1.808
1912	927,116	38,132,000	2.057	1915	968,566	37,330,000	1.961
1913	936,903	34,226,000	1.938				

The oxide concentrating plant was shut down at the time of curtailment in 1914 and had not been reopened before the shutdown in 1915 caused by labor troubles.

Metals produced by Shannon Copper Co., 1911–1915.

Year.	Ore treated.	Copper produced.	Average yield in copper.	Gold.	Silver.	Dividends.
	Short tons.	*Pounds.*	*Per cent.*	*Ounces.*	*Ounces.*	
Year ending August, 1911	263,975	15,168,102	2.845	1,690	91,955	.....
Year ending August, 1912	285,210	16,406,336	2.876	2,615	170,690	$150,000
August to December 31, 1912	95,235	5,149,805	2.704	1,012	54,394	.....
1913	434,307	18,793,724	2.163	3,412	169,197	150,000
1914	193,297	9,003,169	2.33	1,295	60,603	.....
1915	.....	6,017,642	.....	690	35,449	.....

The mines and smelters were closed for five months of the year. The average cost of producing copper in 1915 was 13.4 cents a pound. The company had under construction a 150-ton leaching plant which, it was expected, would be completed by July 1, 1916.

Jerome district.—The production of copper in the Jerome district began about 1883, though it had yielded gold and silver prior to that time. Since 1888 it has been a steady and important producer. To the end of 1915 it has produced 753,440,000 pounds of copper, or 3.52 per cent of the total output of the country since 1845. In total output it stands sixth among the copper districts of the country, and in output for 1915 it ranks tenth.

Copper produced in Jerome district, Ariz., 1911–15.

	Pounds.		Pounds.		Pounds.
1906	38,500,000	1910	38,600,000	1914	30,000,000
1907	33,000,000	1911	33,200,000	1915	53,260,000
1908	36,000,000	1912	31,680,000		
1909	36,700,000	1913	35,300,000		

The rocks[1] in which the United Verde deposit occurs are pre-Cambrian schistose rocks, resulting from the metamorphism of dioritic, rhyolitic, and possibly sedimentary rocks. The material most favorable to replacement by ore is a fissile sericitic schist.

According to Ransome:

> The ore shoot as a whole is of oval plan, its total horizontal length being about 1,300 feet and its greatest width 700 feet. Its general trend is north-northwest and it pitches in that direction at an angle of 45°. It has been worked to a vertical depth of 1,200 feet with no sign of approaching exhaustion. This great shoot is in reality a complex of smaller but nevertheless large irregular or lenticular ore bodies, apparently related in part to cross fissuring but showing a general tendency toward parallelism with the schistosity.
>
> The important ore constituent is chalcopyrite, associated with varying proportions of pyrite and sphalerite. Bornite has been reported but was not noted in 1912. Neither galena nor pyrrhotite was observed at the time of visit. The sulphides occur partly in small irregular fractures and along planes of schistosity, but to a large extent they have metasomatically replaced the schist, particularly the fine-grained sericitic variety. The ore contains very little vein quartz or other gangrene mineral.
>
> The sulphides mentioned are primary and were deposited in pre-Cambrian time.

[1] Graton, L. C., U. S. Geol. Survey Mineral Resources, 1907, pt. 1, p. 597, 1908. Ransome, F. L., U. S. Geol. Survey Bull, 529, p. 192, 1913. Tupper, C. A., Mine and smelter of the United Verde Copper Co.: Min. World, vol. 42, pp. 717–727, 1915.

The ores differ from most of the large copper deposits of Arizona in carrying considerable gold and silver.

As little timber as possible is employed in mining, on account of the danger from fire.[1]

Considerable copper is recovered by precipitation on scrap iron from the mine waters that have leached through the burning stopes.

The United Verde Copper Co. was the most important producer during the year. This company has constructed a new smelting plant[2] for the treatment of its ores at Clarkdale, on the west side of Verde River, about 5 miles from Jerome.

The district is served by a narrow-gage railroad owned by the United Verde Copper Co., which connects with the Santa Fe Prescott & Phoenix Railway.

The directors report the operations of the United Verde Extension Mining Co. as follows:

In December, 1914, a rich body of chalcocite ore was encountered in the southerly end of the original five claims of the company, from which up to December 31, 1915, 3,579 tons of ore averaging 43.9 per cent copper have been shipped; also during the same period 6,173 tons of second-grade ore averaging 17.6 per cent copper occurring close to the high-grade ore have been shipped.

During 1915 the Edith shaft was sunk to the 1,400-foot level and a drift was extended under the productive area on the 1,200-foot level. In January, 1916, a body of ore was encountered which has been described as follows:[3]

There is now developed a body of copper ore of an average width of 150 feet; the longitudinal extent of the ore is still unknown, but it exceeds 275 feet. The body is a massive siliceous chalcopyrite, enriched with chalcocite, and will average throughout the entire body about 15 per cent copper, 1½ ounces silver, and $1 in gold per ton.

Mineral Creek or Ray district.—Notable production in the Mineral Creek or Ray district began in 1911, and the total production to the end of 1915 has been 219,978,000 pounds. The Ray Consolidated Mining Co. has been the only important producer in the district.

Copper produced by Ray Consolidated Mining Co., 1911–1915.

Year.	Ore milled.	Copper content.	Mill recovery.	Refined copper.	Cost per pound.	Dividends.
	Short tons.	*Per cent.*	*Per cent.*	*Pounds.*	*Cents.*	
1911	681,519	1.83	63.1	14,935,047	10.75	.....
1912	1,565,875	1.677	68.278	34,674,275	9.828	.....
1913	2,365,296	1.719	66.09	52,341,029	9.783	$1,631,504
1914	2,427,700	1.76	67.88	57,004,281	8.839	1,089,322
1915	2,848,969	1.673	64.11	60,338,936	9.497	1,872,319

The geology[4] of the district is very similar to that of the Globe district, to the north. Paleozoic sediments have been deposited on a basement of pre-Cambrian schists. In post-Carboniferous time the

[1] Tully, R. E., Mine-fire methods employed by the United Verde Copper Co.: Am. Inst. Min. Eng. Bull. 117, pp. 1546–1553, 1916.

[2] The new plant is described by R. H. Vail (Eng. and Min. Jour., vol. 96, pp. 287–292, 1913).

[3] Eng. and Minn. Jour., April 22, 1916, p. 723.

[4] Ransome, F. L., Geology of the Globe district, Ariz.: Min. and Sci. Press, vol. 102, p. 747, 1911. Weed, W. H., The Ray copper mining district, Ariz.: Min. World, vol. 34, p. 53, 1911. Tolman, C. F., jr., Disseminated chalcocite deposits at Ray, Ariz.: Min. and Sci. Press, vol. 99, p. 622, 1909. Clifford, J. O., Ray Consolidated properties: Mines and Methods, Salt Lake City, Utah, vol. 4, p. 83; Ransome, F. L., U. S. Geol. Survey Bull. 529, p. 186, 1913.

region was invaded by diabase and later by a granitic intrusive of varying composition. After a period of erosion the area was buried beneath Tertiary volcanic and sedimentary rocks. Later it was elevated and faulted, and the covering of Tertiary sediments was partly removed. The ore deposits of the district are of two distinct types—those formed in the sedimentary rocks adjacent to faults and fissures, and disseminated deposits in the schists and granite. The ores of both types are believed to have been introduced at the time of and soon after the granitic intrusion.

The deposits of the fault-fissure type are found east of the Ray fault. The ores are mainly oxidized. To the present time no great production has been made from this type, nor have large ore reserves been developed.

The disseminated deposits occur in crushed schists and "granite." The original mineralization formed pyrite and chalcopyrite, but the commercial ore has resulted from enrichment of the deposits produced by the leaching of the copper from the upper portion and the redeposition of it as chalcocite on the sulphides lower down. This has resulted in a blanket-like deposit of ore, covered by a relatively barren capping and underlain by a zone of original mineralization too low in copper content to be of commercial value.

The average thickness of the leached zone or "capping" in the Ray Consolidated ground is 252 feet, and the average thickness of the ore 101 feet. Locally, especially near the diabase, native copper is of some value.

The district is served by the Arizona Eastern Railroad The mines and reduction works are connected by the Ray & Gila Valley Railroad, controlled by the Ray Consolidated Copper Co.

Ore reserves of the Ray Consolidated Co. at the beginning of 1916 were estimated at 71,911,475 tons, averaging about 2.235 per cent copper. The concentrates were treated at the plant of the American Smelting & Refining Co., at Hayden. The net profits for the year were $4,589,142.

Ajo district.—The Ajo district is in Pima County, about 45 miles from Gila Bend, which is on the Southern Pacific Railroad and with which it has recently been connected by the Tucson, Cornelia & Gila Bend Railroad. Daily service on this road was begun February 20, 1916, from Gila Bend to Cornelia.

The property of the New Cornelia Copper Co. has been under development by the same interests that control the Calumet & Arizona Mining Co. The company estimates the ore as follows: Carbonate ore, 11,954,400 tons, averaging 1.54 per cent copper; sulphide ore, 28,303,600 tons, averaging 1.50 per cent copper; total, 40,258,000 tons, averaging 1.51 per cent copper. Of this, 11,954,400 tons of carbonate ore and 20,526,800 tons of sulphide ore are available for steam-shovel mining. The rocks[1] of the district consist of a series of lavas, breccias, and tuffs which have been intruded by stocks of quartz monzonite porphyry and allied rocks. The original copper deposits consist of small veins containing chalcopyrite and bornite, for the most part in the intrusive rock but also in the extrusive rocks. Oxidation has been extensive, but there has been little leaching of

[1] Joralemon, I. B., The Ajo copper mining district: Am. Inst. Min. Eng. Trans., vol. 49, pp. 593–609, 1914.

the copper from the oxidized ores. It is proposed to extract the copper from the oxidized ores by a leaching process.[1]

A small experimental plant was operated from August 8, 1914, to November 3, 1915, with the following results:

Results of experimental plant of New Cornelia Copper Co., 1915.

Average heads	per cent..	1.325
Average tails	do....	.283
Average extraction	do....	79.0
Average per kilowatt hour	pounds..	1.125

An appropriation of $4,200,000 was made in December, 1915, for the construction of a commercial plant, which is outlined by the general manager, John C. Greenway, as follows:

New plant.—The construction work being prosecuted, which, when completed, will put the New Cornelia property on a production basis of 36,000,000 pounds of copper per year, may be briefly described as follows:

This mine will be opened up so that three 100-ton steam shovels can be used for loading the ore into cars. The ore will be hauled approximately 1 mile to the treatment plant, where it will be dumped directly from the cars into a large gyratory crusher. Five 70-ton switch locomotives and fifty 20-yard side-dump cars will be used on this mine service and ore haulage.

Coarse crushing plant.—The coarse crushing plant will be equipped with 1 No. 24 gyratory crusher, 4 No. 8 gyratory crushers, the driving motors, and an electric traveling crane.

Storage bins.—From the coarse crushing plant the ore crushed down to about 3½ inches in size will be conveyed to the fine storage bins, having a storage capacity of 10,000 tons.

Fine crushing plant.—From the storage bins the ore will be conveyed to the fine crushing plant, where it will be crushed down to one-fourth inch in size. This plant will contain 12 Symons disk crushers and an electric traveling crane, with the necessary motor equipment. An ore-sampling plant will be located between the fine crushing plant and the leaching plant.

Leaching plant.—From the crushing plant the ore will be conveyed to the leaching tanks, where it will be bedded in even layers throughout, the tank being filled. There will be 11 lead-lined leaching tanks, each 88 feet square by 15 feet deep inside, having a capacity of 5,000 tons of ore each, and 1 sludge tank of the same dimensions. Each leaching tank will have its pumping equipment for circulating and advancing its solution at the rate of about 8,000 gallons per minute. The leaching tanks will be arranged in two rows with a central structure between, which will support the conveyors conveying the ores to the tanks and the circulating pumps and necessary launders. After the copper is extracted from the ore and the tailings washed and drained, they will be loaded into cars by an excavator of the Hulett type. The tailings will be hauled to the dump in side-dump cars on the afternoon shift, the cars and locomotives used at the mine on the morning shift being available for this service.

This plant will have 5 wash-water and acid-solution storage tanks of 430,000 gal-gallons capacity each.

Electrolytic plant.—The neutral solution from the leaching plant will be pumped to 4 sulphur dioxide absorption towers, approximately 20 feet in diameter and 40 feet high, for the reduction of the ferric iron to suit the requirements of the electrolytic plant. From the absorption towers the solution will be pumped to the electrolytic plant, where it will be circulated through the electrolytic cells and the acid solution returned to the leaching plant. The tank house will consist of two main aisles, each 80 feet wide and 270 feet long, and will contain 152 lead-lined electrolytic tanks approximately 30 feet long, 4 feet wide, 5 feet deep, with the necessary cranes, pump circulating equipment, and sumps.

Power plant.—The power-plant building will be steel and concrete and approximately 126 feet wide by 200 feet long. The boilers and turbines will be in the same building, but separated by a partition. The boiler room will contain five 822.6 horsepower Stirling boilers set for oil firing, the economizers, and the feed water equipment. The turbine room will contain two 7,500-kilowatt steam turbines, the motor-driven, direct-current apparatus for the electrolytic plant, and the switchboard.

[1] Croasdale, Stuart, Leaching experiments on the Ajo ores: Am. Inst. Min. Eng. Trans., vol. 49, pp. 610–658, 1914.
Morse, H. W., and Tobelmann, H. A., Leaching tests at New Cornelia: Am. Inst. Min. Eng. Bull. 117, pp. 1593–1610, 1916.

Shops and warehouse.—The old smelter building at Douglas is being used to house the shops and warehouse. A space 180 feet by 80 feet will be devoted to the shops. Modern shops, tools, and equipment are being installed to take care of the repair work for the mine and plant. A space 80 feet by 60 feet has been set apart for the warehouse.

Storage tanks, etc.—The plant will be provided with a water-storage tank of 300,000 gallons capacity at a suitable elevation. Two oil tanks of 15,000 barrels capacity each and four acid tanks of 150,000 gallons will be provided and located with reference to the unloading tracks, so that oil and acid will flow by gravity directly from the cars to the tanks.

Water supply.—Further work will be done in water development, and an electric-driven pump with a capacity of 750 gallons per minute will be installed at No. 1 well. A 10-inch pipe line will be laid from No. 1 well to the storage tank at the plant.

Office and laboratory.—A suitable general office and laboratory will be constructed at the plant.

Probable completion of plant.—Provided delivery of materials is satisfactory, it is estimated that the plant will be ready for operation on or before July 1, 1917.

Turquoise district.—Shipments of copper from the Turquoise district during the year amounted to about 2,048,000 pounds. The Paleozoic sediments [1] of the district have been extensively faulted and intruded by monzonitic porphyries. The copper deposits of the district may be grouped as follows: (1) Oxidized blanket deposits connected with thrust faulting, exemplified by the ore bodies of the Germania and Mary mines; (2) pyritic deposits with some associated bodies of oxidized ore in the Cambrian dolomitic limestone and shale, exemplified by the Mame and Leadville mines; (3) pyritic deposits with associated bodies of oxidized or enriched ore in Carboniferous limestone, exemplified by the Copper Belle and other mines near Gleeson.

Silverbell district.—The Silverbell district, in Pima County, showed little activity in 1915, as for several years previous. Noteworthy copper production in the district began in 1904, though it has produced some silver and a little copper before that date. To the end of 1915 the district has produced about 41,800,000 pounds of copper.

Paleozoic sediments [2] have been intruded by an acidic porphyry, the sedimentary formation being for the most part represented by detached blocks entirely surrounded by porphyry. The copper deposits are of two types—contact deposits, in which the sulphides of iron and copper, together with contact silicates, garnet, epidote, etc., have replaced limestone; and disseminated deposits, in which the original ores consist of iron and copper sulphides as veinlets and small grains in the shattered porphyry. The workable ores of the latter type in this district, as in most others, have resulted from the enrichment of these deposits.

The ores mined were principally of the contact type. These ores were in general rather low-grade smelting ores. However, they were nearly or quite self-fluxing and were therefore treated cheaply. Development of the disseminated ores was carried on about 1910, and encouraging results were reported, but no production has since been made from this type.

The ores of the district were treated at the plant of the Southern Arizona Smelting Co., at Sasco. This plant was closed August 16, 1910, and has remained idle since.

A branch of the Southern Pacific Railroad extends from Red Rock to the district.

The Imperial Copper Co. was the main producer of the district.

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[1] Ransome, F. L., The Turquoise copper-mining district, Ariz.: U. S. Geol. Survey Bull. 530, pp. 125–134, 1912.

[2] The district has been briefly described by C. F. Tolman, jr. (Min. and Sci. Press, vol. 99, 1909, p. 710). See also Stewart, C. A., the geology and ore deposits of the Silver Bell mining district, Ariz.: Am. Inst. Min. Eng. Trans., vol. 43, pp. 240–290, 1913.

Pioneer district.[1]—The Magma Copper Co., of the Pioneer district, Pinal County, produced 6,046,459 pounds of copper in 1915, at an average cost of 6.82 cents a pound, the operating profits being $670,886. The ore bodies are reported to occur "in a strong fault fissure filled with porphyry and cutting diabase, quartzite, and limestone."

Other districts.—Other districts making noteworthy production of copper in 1915 were the Cochise district, Cochise County; the Pima district, Pima County; and the Big Bug district, Yavapai County.

CALIFORNIA.

In 1915 California produced 37,658,444 pounds of blister copper, compared with 29,784,173 pounds in 1914.

California was among the earliest of the Western States to make a considerable output of copper. Production began in the "foothill" belt about 1862, and for several years California was second only to Michigan in output of copper. Later, however, the industry declined, and California did not again attain high rank as a copper producer until 1897, when production from the Shasta County district began. Since that time the State's output has been steady and large. The production for the early years has been ascertained from the best sources available, and adding to this the known production since 1882, it is found that to the end of 1915 California has produced about 612,421,961 pounds of copper, or 2.87 per cent of the output of the country since 1845. In 1915 the output was 2.71 per cent of the total production of the United States. In total output the State ranks fifth among the copper producers of the country, and for 1915 it ranked eighth. Three smelting plants in the State treated copper ores in 1915.

Most of the copper has come from two districts, though numerous other districts have made small outputs, and copper minerals are widely distributed over the State. The largest producer has been the Shasta County district.

Shasta district.—The Shasta County copper belt lies in the Klamath Mountains, at the head of the Sacramento Valley, a few miles north of Redding. Sacramento River crosses the belt, separating it into an eastern and a western portion; the eastern portion contains the Bully Hill and Afterthought districts, and the western the Iron Mountain and Little Backbone districts. Placer mining was carried on in the county in the early days of mining in the State, and later considerable silver was produced from the gossan outcrop of the copper deposits. Copper minerals had been long known in the county, but not until 1897, when the Mountain Copper Co. (Ltd.) began production at Iron Mountain, did it become an important contributor of copper.

Copper produced in Shasta County districts, Cal., 1906–1915.

Year.	Quantity (pounds).	Average yield of copper (per ct.).	Gold and silver per ton.	Year.	Quantity (pounds).	Average yield of copper (per ct.).	Gold and silver per ton.
1906	21,000,000	3.6	$3.75	1911	29,900,000	3.7	$1.80
1907	28,000,000	3.0	2.70	1912	26,000,000	3.58	1.84
1908	32,000,000	3.2	2.85	1913	26,800,000	3.50	1.76
1909	48,000,000	3.4	2.02	1914	25,100,000	3.56	1.70
1910	36,000,000	3.0	2.14	1915	30,500,000	3.29	2.09

[1] Ransome, F. L., Copper deposits near Superior, Ariz.: U. S. Geol. Survey Bull. 540, pp. 139–158, 1912.

The total production to the end of 1915 has been about 474,300,000 pounds, or 2.22 per cent of the total output of the country. In 1915 the district produced 2.05 per cent of the total output. In total output the district ranks eighth and in the production for 1915 it was twelfth among the copper districts of the country.

The inclosing rock [1] of most of the ore bodies is an intrusive alaskite porphyry of Mesozoic age. The ore minerals have replaced this rock along fissures and zones of shearing. In the western district the largest deposits thus far developed are large flat-lying, more or less tabular bodies of no great vertical extent. Deposits having more the character of veins and containing a relatively high percentage of chalcopyrite have been worked in recent years. In the eastern district the ore bodies have more definitely the character of veins and locally occur in the sediments adjoining the porphyry.

The sulphide lenses in the western district contain pyrite, a small percentage of chalcopyrite, and varying quantities of sphalerite. In some places the sphalerite is sufficiently abundant to make the deposit a valuable zinc ore. The vein deposits in the western area are siliceous and contain a relatively high percentage of chalcopyrite. In the eastern district sphalerite is a notable constitutent. Rich secondary sulphide ores were found underlying the gossan at Iron Mountain and Bully Hill, but these have been exhausted.

The principal producing companies in 1915 were the Mountain Copper Co., Mammoth Copper Co., and Balaklala Copper Co. The ores of the Mammoth Co. were smelted at its plant at Kennett, and the Mountain Co.'s ores were smelted at its plant at Martinez, on San Francisco Bay. The Balaklala ores were shipped to the Mammoth plant.

The Mammoth Copper Mining Co. produced 251,907 tons of copper ore and 44,766 tons of zinc ore. The zinc ore was sorted and shipped to the Central States for treatment. The ore as mined averaged about 4 per cent copper and $2 per ton in gold and silver. Mining costs were $1.56 per ton, and cost of exploration and development averaged $0.59 per ton. Exploration in sec. 29 revealed additional small bodies of high-grade ore. A crosscut tunnel started on the Friday Londen group is expected to intersect the Mammoth ore zone 400 feet below the No. 5 or main working tunnel. It is estimated that the tunnel will reach the Mammoth ore zone 4,000 feet from the portal.

In the Stowell group, which is being developed under bond, 48,100 tons of ore averaging 3.71 per cent of copper and $1.50 per ton in gold has been blocked out.

Prospecting in the Spread Eagle group has disclosed no ore, but it is reported that indications are encouraging.

The Mountain Copper Co. treated 114,285 tons of ore and concentrates, derived as follows: Iron Mountain mine, 17,302 tons; No. 8 mine, 35,204 tons of ore and 5,619 tons of concentrates; Hornet mine, 55,201 tons; purchased ore, 959 tons. The output of copper was 3,584 tons. The ore reserves at the end of the year were estimated as follows:

[1] Diller, J. S., U. S. Geol. Survey Geol. Atlas, Redding folio (No. 138), 1906; U. S. Geol. Survey Bull. 213, pp. 123–132, 1903; U. S. Geol. Survey Bull. 225, pp. 169–179, 1904. Graton, L. C., The occurrence of copper in Shasta County, Cal.; U. S. Geol. Survey Bull. 430, p. 71, 1910. Boyle, A. C., Geology and ore deposits of the Bully Hill mining district, Cal.: Am. Inst. Min. Eng. Bull., pp. 57–105. January, 1914, Hershey, O. H., The geology of Iron Mountain: Min. and Sci. Press, Oct. 23, 1915, pp. 633–638.

Ore reserves of Mountain Copper Co., 1915.

	Tons.
Fully developed:	
No. 8 mine	137,500
Complex mine	30,000
Partly developed and probable:	
No. 8 mine	50,000
Complex mine	45,000

The quantity of available ore in the Hornet mine above the present working tunnel is estimated at 370,000 tons. In addition it was estimated in an earlier report that about 3,000 tons of ore still remains in the old mine. The reserves in the No. 8 and Complex mines are estimated to average 3 per cent copper. That of the Hornet is low in copper but high in sulphur.

The concentrating plant was readjusted immediately after the beginning of operations and is reported to have given satisfactory results.

The Balaklala smelter at Coram, built to treat the ores of the Balaklala and Trinity mines, has been idle for several years on account of difficulty in controlling smelter fumes. During 1915 ore from the Balaklala mine was shipped to the Mammoth smelter.

For some time experiments have been carried on at Bully Hill to develop a method for the electrolytic treatment of the zinc-copper ores that would obviate the difficulty with fumes that caused the closing of the smelter and permit the recovery of both copper and zinc. Before the end of 1915 the work had advanced to the stage in which some metal was produced.

The smelter at Afterthought has not been operated for several years. The ores of the district, like those of the Bully Hill district, are high in zinc and will doubtless be amenable to any treatment that proves successful with the Bully Hill ores.

Electric power is used almost exclusively at both mines and reduction plants.

The Shasta County belt is served by the Southern Pacific Railroad, which has short branches extending to the smelters. The Iron Mountain district is connected with the main line by a narrow-gage railroad operated by the Mountain Copper Co., and the mines of the Mammoth Co. are connected with the smelter by a combined electric railroad, gravity tram, and steam railroad. The ores of the Balaklala and Trinity mines are delivered to the railroad over a cable tramway. The Bully Hill district is served by a standard-gage branch of the Southern Pacific Railroad. The nearest railroad point to the Afterthought district is Bellavista, on the Anderson & Bellavista Railroad, at a distance of about 15 miles.

"Foothill" district.—The "foothill" belt is a rather extensive area of copper deposits which has its best development in Calaveras County. This belt furnished practically the entire copper production from California in the sixties. Subsequent to that period the district was inactive for many years, but from 1887 to 1892 the mines again made some production. The present period of activity began about 1901, and for some years the district has made important contributions to the copper output of the State.

There is no accurate record of the output of this district in the early days, but from the records of the production of the State it is

estimated that to the end of 1915 it has yielded approximately 129,400,000 pounds of copper.

Copper produced in "foothill" district, Cal., 1907–1915.

Year.	Quantity.	Average yield.	Year.	Quantity.	Average yield.
	Pounds.	*Per cent.*		*Pounds.*	*Per cent.*
1907	4,500,000	5 +	1912	6,000,000	5.1
1908	4,500,000	4	1913	5,800,000	4.5
1909	5,400,000	4.6	1914	4,400,000	5.0
1910	8,000,000	5.2	1915	3,700,000	5.44
1911	5,500,000	4.7			

In total output the district ranks thirteenth, and in production for 1915 it ranked twentieth among the copper districts of the country.

The ores,[1] consisting of pyrite and chalcopyrite, occur as lenticular bodies replacing schistose rocks. The ores vary in different parts of the district from those carrying nearly pure pyrite and chalcopyrite with very low gold and silver content to ores carrying considerable lead, zinc, and precious metal. The ores treated during 1915 averaged about 5.4 per cent in copper and about 3.1 cents in precious metals per pound of copper.

Most of the copper was produced by the Penn Mining Co., Campo Seco, and the Calavaeras Copper Co., Copperopolis. The matte smelter of the Penn Mining Co. was operated.

Other districts.—Copper was produced in 1915 at the Engels mine, in Plumas County, about 30 miles northwest of Keddie, on the Western Pacific Railway, the nearest shipping point. A concentrating plant employing the flotation process was constructed in 1914. According to Turner and Rogers,[2] the primary ores formed as a direct crystallization from a dioritic magma. The metallic minerals are magnetite, hematite, chalcopyrite, and bornite. Later solutions produced chalcocite, covellite, and chalcopyrite.

Small amounts of copper were also produced in Placer, Inyo, and other counties.

COLORADO.

In 1915 Colorado produced 7,272,178 pounds of blister copper, compared with 7,316,066 pounds in 1914. Although the State has no important producing district in which copper is the principal metal, yet it ranked tenth among the copper-producing States in 1915. The total recorded output for the State from the beginning of the industry has been 246,654,700 pounds, or 1.16 per cent of the total for the United States since 1845. It is probable that the actual output is somewhat in excess of this figure, as some of the copper assigned in the earlier Survey reports to "lead desilverizers" should doubtless be credited to Colorado.

The copper has been derived mainly from the treatment of mixed ores in which copper was a minor constituent, including lead-silver

[1] Knopf, Adolph, California Univ. Dept. Geology Bull., vol. 4, p. 411, 1906. Read, J. A., Econ. Geology, vol. 2, p. 380, 1907. Lang, Herbert, Eng. and Min. Jour., vol. 84, p. 909, 1907.

[2] Turner, H. W., and Rogers, A. F., A geologic and microscopic study of a magmatic copper sulphide deposit in Plumas County, Cal., and its modification by ascending secondary enrichment. Econ. Geology, vol. 9, pp. 359–391, 1914. The general geology of the region is described by J. S. Diller in U. S. Geol. Survey Bull. 353.

ores and pyritic ores rich in gold and silver. In 1915 the largest production came from Lake County and from San Juan, Ouray, San Miguel, Clear Creek, Chaffee, Dolores, Gilpin, and Fremont counties. Leadville and the San Juan-Ouray region have been the greatest producers of copper. Much of the output is recovered as matte in lead furnaces.

IDAHO.

During 1915 Idaho produced 6,217,728 pounds of blister copper, compared with 5,875,205 pounds in 1914. The State has made a small and irregular output of copper since 1884, but only since 1903 has it been a steady and important producer. To the end of 1915 it had a recorded output of 87,058,408 pounds.

Coeur d'Alene district.—The Coeur d'Alene district has been the most productive copper district in the State. Complete figures for the copper output of the district are not on record, but the total production has been approximately 58,600,000 pounds. The Snowstorm mine has been the largest copper producer in the district. At this mine the deposit[1] consists of disseminated bornite, chalcocite, and chalcopyrite in certain beds of a pre-Cambrian quartzite; in the upper portion the deposit is oxidized. The lode ranges from a few feet to 40 feet in width and has been developed by tunnels to a depth of 1,200 feet below the outcrop.

Loon Creek district.—There has been intermittent production from the Loon Creek district for several years, mainly from the Lost Packer mine. This mine[2] is developed on a fissure vein in mica schist. The principal metallic mineral is chalcopyrite, which is accompanied by subordinate pyrite and pyrrhotite and variable amounts of siderite. Quartz is the principal gangue mineral. Some of the ore has a high gold content and some silver.

A 100-ton matte smelter was completed in 1905 and has made several successful runs in spite of the high cost of coke and other supplies that are freighted 110 miles from Mackay.

Alder Creek district.—There has been intermittent production from the Alder Creek or Mackay district since 1900. The copper deposits[3] occur associated with blocks of limestone surrounded by granite porphyry. They are of the type generally termed contact deposits. According to Umpleby the location of the deposits has been determined by the blocks of limestone, although both the limestone and the adjacent granite porphyry have been converted to garnet and other contact minerals. The primary ore consisted mainly of chalcopyrite, with subordinate pyrite and pyrrhotite, in a silicate gangue composed chiefly of garnet. Oxidized ores made up of silicate carbonate and oxide have furnished much of the material mined.

There are other districts in Idaho, notably that of the Seven Devils region,[4] that contain copper deposits, but owing to lack of transportation facilities they have made but small production.

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[1] Ransome, F. L., and Calkins, F. C., The geology and ore deposits of the Coeur d'Alene district, Idaho: U. S. Geol. Survey Prof. Paper 62, pp. 150–152, 1908. Calkins, F. C., and Jones, E. L., jr., Economic geology of the region around Mullan, Idaho, and Saltese, Mont.: U. S. Geol. Survey Bull. 540, pp. 167–211, 1914.

[2] Umpleby, J. B., A preliminary account of the ore deposits of the Loon Creek district, Idaho: U. S. Geol. Survey Bull. 530, p. 70, 1913.

[3] Umpleby, J. B., Genesis of the Mackay copper deposits, Idaho: Econ. Geology, vol. 9, pp. 307–358, 1914.

[4] Lindgren, Waldemar, The copper deposits of the Seven Devils: U. S. Geol. Survey Twentieth Ann. Rept., pt. 3, pp. 249–253, 1900.

MICHIGAN.

The production of refined copper in Michigan in 1915 was 238,956,410 pounds, compared with 158,009,748 pounds in 1914. This output marked a high record for the Lake district. The notable increase over each of the last two years was due largely to abnormally low production in 1913 and 1914 caused by labor troubles and unfavorable market conditions.

The mining of copper in Michigan antedates the earliest visits of European explorers to the region. The production on a commercial scale, however, dates from 1845, and since that time the State has been a steady producer and an important factor in the copper industry of the world. To the end of 1915 Michigan has produced 5,758,399,050 pounds of copper, or 26.93 per cent of the output from the United States since 1845. For many years subsequent to 1845 Michigan was the most important copper-producing State, and in total output it is second only to Montana. The entire output comes from the Keweenaw or Lake Superior district.

In the value of metal output, in the profits resulting from this output, in the development of mining and metallurgic processes, and in the general high standing of the companies conducting the operations the district takes high rank among the great mining camps of the world. Prior to the perfection of the electrolytic process of refining, Lake copper enjoyed the distinction of being the highest grade produced, and even to the present time it commonly sells at a figure slightly higher than the copper from other districts.

Although the district has been an active producer for 70 years, most of the older mines still have large reserves of ore, new mines are being opened, and much territory remains to be prospected. Moreover, large quantities of the mill tailings produced when milling methods were less efficient than at present are being re-treated at a profit. During 1915 the White Pines Co., which has been developing and equipping its mine for several years, became a producer.

The Lake Superior region is unique in being the only district in which a large output is derived from native copper. The rocks [1] of the district comprise a thick series of rather basic lava flows and intercalated beds of conglomerate and sandstone of pre-Cambrian age. These have been tilted so that they have a northwest dip, usually rather steep, and strike in a general northeast direction. The copper occurs in the cellular portions of the lava flows, which form the amygdaloid lodes, and as a cement and to some extent as a replacement of the conglomerate pebbles forming the conglomerate lodes. Copper also occurs in fissures crossing the formations, but at present these are of little commercial importance, though in the early days of the district considerable copper was derived from deposits of this type. A little native silver occurs with the copper. The lodes are of low grade but are of great extent and show a rather uniform distribution of the metallic content. This condition, together with

[1] For detailed description of the geology and mining, see Irving, R. D., U. S. Geol. Survey Mon. 5, 1883; Michigan Geol. Survey, vols. 5 and 6; Rickard, T. A., Eng. and Min. Jour., vol. 88; Pumpelly, Raphael, Michigan Geol. Survey, vol. 1, 1873; Lane, A. C., and Hubbard, L. L., Michigan Geol. Survey, vol. 4, 1898; Rominger, C., Michigan Geol. Survey, vol. 5, 1905; Rice, C. T., Copper mining at Lake Superior: Eng. and Min. Jour., vol. 94, pp. 119, 171, 217, 307, 365; Hore, R. S., Mineral resources of Michigan: Michigan Geol. and Biol. Survey, pp. 15–115, 1911; Van Hise, C. R., and Leith, C. K., The geology of the Lake Superior region: U. S. Geol. Survey Mon. 52, pp. 573–591, 1911.

the fact that the ore is susceptible of high concentration with low cost of refining the resultant "mineral," makes it possible to work these low-grade deposits at a good profit. The native copper occurs in the lodes in masses ranging from those of microscopic size to bodies weighing hundreds of tons. The richest lode mined at present yields less than 1.5 per cent copper, and the poorest rock treated yields but little above 0.5 per cent. To derive a profit from this low-grade ore it must be handled on a large scale; this has resulted in the construction of the immense plants that characterize the Lake district. The lodes are worked for the most part through inclined shafts, though some of the deeper deposits are opened by vertical shafts. The workings have been extended in some places to a mile in vertical depth, or about a mile and a half down the lode. Pillars of rock are left to keep the lodes open, and dry walls constructed from the waste sorted underground serve the same purpose in some of the mines. Much timber, however, is required in some of the mines, especially those operating on the conglomerate lodes.

The "rock" coming from the mines is crushed by steam stamps and concentrated, producing "mineral" containing an average of about 65 per cent copper. In recent years regrinding plants have been constructed for the finer grinding and concentration of material that had previously been discarded as tailings. The "mineral" is subjected to a combined smelting and refining process. A small amount of "mass" and "barrel work" copper is sorted out at the mine and goes direct to the smelter. A portion of the output (during 1915 about 20 per cent) is refined electrolytically. This consists of copper sufficiently argentiferous to make the recovery of silver profitable, and of copper containing so high a percentage of impurities that further refining is necessary for certain uses.

Silver in important quantity is recovered only from the copper treated electrolytically. The average recovery per ton of rock from which the copper was refined electrolytically was approximately 0.30 fine ounce.

Copper ore produced in Lake Superior district, Mich., 1906–1915.

Year.	Quantity.	Yield of copper.	Year.	Quantity.	Yield of copper.
	Short tons.	*Per cent.*		*Short tons.*	*Per cent.*
1906	8,904,127	1.26	1911	10,978,827	1.00
1907	9,892,214	1.1	1912	11,411,941	.96
1908	10,531,271	1.06	1913	7,016,370	.97
1909	11,429,394	1.02	1914	9,269,413	.89
1910	10,869,561	1.02	1915	12,334,700	1.07

The statistics in the following tables are compiled from the annual reports to the stockholders of the individual companies.

Copper ore milled by Michigan mines, 1906–1915, in short tons.

Mine.	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Ahmeek				406,045	530,365	598,549	652,260	383,749	590,519	948,874
Allouez	178,400	214,720	220,905	253,049	247,119	288,610	333,618	236,663	354,457	534,705
Baltic	649,932	761,288	764,117	814,260	781,419	696,795	652,433	333,289	324,433	378,443
Calumet & Hecla				2,842,880	2,795,514	2,909,972	2,806,610	2,035,625	2,592,462	3,188,583
Centennial	166,000	200,040	169,693	196,525	102,133	86,543	106,517	85,443	138,136	150,191
Champion	671,785	708,685	794,703	753,908	722,051	734,392	765,306	421,849	614,854	923,743
Franklin	372,378	383,290	342,596	170,546	113,859		176,462	123,179	7,324	122,018
Gratiot					28,522	1,347				
Hancock						41,449				
Houghton										14,657
Isle Royale	192,210	175,450	218,940	401,280	520,860	457,440	531,105	314,679	474,349	680,270
Lake								19,211		
La Salle					35,520	18,940		2,221	45,509	80,959
Mass	185,789	204,599	171,268	139,404	90,747	73,475	132,891	78,250	209,354	323,335
Michigan	140,225	150,407	190,548	146,971						
Mohawk	618,534	640,777	685,823	819,019	802,537	802,548	787,941	366,458	649,649	829,789
Osceola	1,016,240	811,603	1,241,400	1,494,845	1,217,720	1,246,596	1,246,557	735,044	1,108,447	1,361,089
Quincy						1,382,524	1,309,253			
Superior				81,641	140,514	162,599	172,322	130,826	191,628	212,051
Tamarack	389,680	532,400	654,897	689,099	525,554	392,338	421,385	227,563	57,410	217,027
Trimountain	506,924	444,358	334,929	323,408	317,299	347,885	366,663	229,149	277,251	349,684
Victoria					122,497	126,894	131,955	137,163	124,842	133,984
White Pines										[a] 114,039
Winona						97,445	181,148	120,806	123,339	102,594
Wolverine	352,890	340,613	360,055	390,837	388,476	401,308	388,502		182,127	397,614

[a] Last 8 months of 1915.

Copper yield per ton of ore milled by Michigan mines, 1906–1915, in pounds.

Mine.	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Ahmeek	.....	.....	.....	22.07	22.33	25.4	25.2	24.0	23.1	23.0
Allouez	19.54	13.66	13.79	15.93	18.84	16.56	16.56	17.29	17.09	18.78
Baltic	22.15	21.94	23.20	21.88	22.46	22.06	20.50	23.21	21.58	31.79
Calumet & Hecla	.....	.....	.....	28.18	25.77	25.47	24.18	22.11	20.70	22.28
Centennial	13.58	11.86	12.94	13.15	15.40	17.26	16.36	18.87	16.56	15.63
Champion	25.2	23.27	22.39	23.88	26.62	21.30	22.51	28.64	25.71	36.17
Franklin	12.27	11.48	10.82	9.47	8.49	.....	9.80	8.29	12.73	.....
Gratiot	.....	.....	.....	.....	9.32	10.60	.....	.....	.....	.....
Hancock	.....	.....	.....	.....	.....	18.21	.....	.....	.....	.....
Houghton	.....	.....	.....	.....	.....	.....	.....	.....	.....	10.69
Isle Royale	15.3	15.2	13.75	14.30	14.53	16.4	15.4	13.2	13.9	13.7
Lake	.....	.....	.....	.....	.....	.....	.....	14.95	.....	.....
La Salle	.....	.....	.....	.....	13.29	14.77	.....	19.76	11.88	9.67
Mass	11.3	10.16	10.31	12.36	14.59	17.58	15.39	15.51	.....	14.35
Michigan	20.4	17.72	15.74	13.47	.....	.....	.....	.....	.....	.....
Mohawk	15.12	15.77	15.01	13.73	14.22	15.07	15.22	15.76	17.08	19.15
Osceola	18.3	17.4	17.11	16.90	15.90	14.8	14.8	15.4	13.5	14.5
Quincy	.....	.....	.....	.....	.....	16.10	15.76	.....	.....	.....
Superior	.....	.....	.....	21.82	22.64	19.90	22.76	22.87	16.79	18.23
Tamarack	25.2	20.8	19.55	19.60	21.10	19.1	18.8	18.3	18.7	17.9
Trimountain	18.76	18.43	18.02	16.33	17.95	17.59	19.04	21.78	18.21	23.75
Victoria	.....	.....	.....	.....	9.51	10.53	9.28	10.42	11.9	.....
White Pines	.....	.....	.....	.....	.....	.....	.....	.....	.....	24.76
Winona	.....	.....	.....	.....	.....	13.09	12.74	11.99	10.96	16.79
Wolverine	27.06	27.22	26.54	24.96	24.75	23.45	21.49	.....	18.86	18.23

Copper produced by Michigan mines, 1906–1915, in pounds.

Mine.	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Adventure	1,552,628	1,244,874	90,870							
Ahmeek				9,198,110	11,844,954	15,196,127	16,455,769	9,220,874	13,634,605	21,800,492
Allouez	3,486,900	2,934,116	3,047,051	4,031,532	4,655,702	4,780,494	5,525,455	4,091,129	6,056,548	10,043,459
Atlantic	1,439,082							44,370		
Baltic	14,397,557	16,704,868	17,724,854	17,817,836	17,549,762	15,370,449	13,373,961	7,736,124	7,001,945	12,028,947
Calumet & Hecla				80,096,995	72,059,545	74,130,977	67,856,429	45,016,890	53,691,562	71,030,518
Centennial	2,253,015	2,373,572	2,196,377	2,583,793	1,572,566	1,493,834	1,742,338	1,612,262	2,287,130	2,347,500
Champion	16,954,986	16,489,436	17,786,763	18,005,071	19,224,124	15,639,426	17,225,508	12,080,594	15,807,206	33,407,599
Franklin	4,571,570	4,401,248	3,707,518	1,615,556	966,353	820,203	1,710,651	1,021,440	93,283	1,314,969
Gratiot					265,869	14,275				
Hancock						754,749				871,124
Houghton										156,766
Isle Royale	2,937,098	2,667,608	3,011,664	5,719,056	7,567,399	7,490,120	8,186,957	4,158,548	6,601,235	9,342,106
Lake								287,200		
La Salle					472,100	280,598		43,906	540,731	782,493
Mass	2,106,739	2,078,677	1,766,930	1,723,436	1,321,885	1,326,898	2,045,006	1,213,545		4,638,452
Michigan	2,875,341	2,665,404	3,000,206	1,979,305						
Mohawk	9,352,252	10,107,266	10,295,881	11,248,474	11,412,066	12,091,056	11,995,598	5,778,235	11,094,859	15,882,914
Osceola	18,588,451	14,134,753	21,250,794	25,296,657	19,346,566	18,388,193	18,413,387	11,325,010	14,970,737	19,731,472
Quincy	16,194,838	19,796,058	20,600,361	22,511,984	22,517,014	22,252,943	20,634,800	12,184,128	15,356,380	22,054,813
Superior				1,781,315	3,181,041	3,236,233	3,921,974	2,992,765	3,217,635	3,866,484
Tamarack	9,832,644	11,078,604	12,806,127	13,533,207	11,063,606	7,494,077	7,908,745	4,168,743	1,074,808	3,888,150
Trimountain	9,507,933	8,190,711	6,034,908	5,282,404	5,694,868	6,120,417	6,980,713	4,990,938	5,048,306	8,302,896
Victoria	546,334	1,207,337	1,290,040	1,062,218	1,164,564	1,303,331	1,224,911	1,428,693	1,486,242	1,499,695
White Pines										2,824,145
Winona	278,182	1,285,863				1,275,675	2,307,237	1,448,737	1,352,085	1,722,638
Wolverine	9,548,123	9,272,351	9,555,233	9,757,101	9,617,168	9,408,960	8,350,312		3,435,459	7,250,866

Cost per pound of copper produced by Michigan mines, 1910–1915, in cents.

Mine.	1910	1911	1912	1913	1914	1915
Ahmeek	11.05	7.17	7.85	13.30	9.71	7.96
Allouez	11.57	13.30	13.52	12.09	11.18	9.31
Baltic	8.32	9.09	10.94	11.91	11.17	9.50
Calumet & Hecla	8.96	8.52	9.86	14.25	11.35	9.33
Centennial	14.48	12.69	13.46	13.38	12.56	12.45
Champion	7.85	9.63	8.88	10.71	9.21	6.30
Franklin	14.63	.....	.....	.....	.....	.....
Isle Royale	11.84	10.850	11.89	18.81	13.05	14.94
Mohawk	11.44	10.399	10.61	13.22	8.58	7.21
Osceola	9.37	9.28	10.36	12.30	10.79	10.03
Quincy	10.48	.....	.....	.....	.....	.....
Superior	14.29	15.31	12.75	12.86	12.43	12.29
Tamarack	14.70	15.56	13.15	16.60	29.08	17.07
Trimountain	12.17	11.55	11.73	12.62	12.21	9.53
White Pines	.....	.....	.....	.....	.....	16.64
Wolverine	7.542	7.586	8.66	.....	11.72	8.43

Dividends paid by Michigan mines, 1911–1915.

Company.	1911	1912	1913	1914	1915
Ahmeek	$250,000	$1,100,000	$850,000	$200,000	$1,650,000
Allouez	.....	.....	.....	.....	200,000
Baltic	500,000	700,000	200,000	.....	.....
Calumet & Hecla	2,400,000	4,200,000	3,200,000	1,000,000	5,000,000
Champion	500,000	1,100,000	900,000	.....	3,100,000
Isle Royale	.....	.....	150,000	.....	.....
Mohawk	175,000	350,000	500,000	100,000	600,000
Osceola	673,050	1,153,800	721,125	288,450	1,057,650
Quincy	440,000	550,000	412,500	55,000	880,000
Trimountain	.....	300,000	200,000	.....	.....
Wolverine	540,000	600,000	300,000	120,000	240,000

The district is well located for cheap working of the mines. The Great Lakes furnish cheap transportation for both coal and copper, and the Lake steamers reach the heart of the district by Portage Lake and the Houghton Ship Canal. The district is served by the Mineral Range, Copper Range, and Keweenaw Central railroads and is connected with the main lines of traffic by the Chicago, Milwaukee & St. Paul and Duluth, South Shore & Atlantic railways.

MONTANA.

The output of blister copper from Montana in 1915 was 268,263,040 pounds, compared with 236,805,845 pounds in 1914.

The first record of production of copper from Montana is for 1868, but the State did not become an important contributor of this metal until 1880. Since that time there has been a steady and rapid increase in its copper output. To the end of 1915 the State has produced 6,703,097,139 pounds, or 31.32 per cent of the total output of the United States since 1845. In total production the State ranks first, and in the output for 1915 it ranked second. The Butte district has furnished nearly the entire output.

Three copper-smelting plants were operated in Montana in 1915—that of the East Butte Mining Co., at Butte, and those of the Anaconda Copper Co., at Anaconda and at Great Falls.

Butte district.—The presence of copper minerals in the Butte district has been known since the discovery of gold in 1864, and attempts were made to treat the ores as early as 1866; but it was not until the

late seventies that Butte began to attract attention as a copper camp, and large production did not begin until a railroad reached the district in 1881. To the end of 1915 Butte has produced about 6,680,500,000 pounds of copper, or 31.24 per cent of the total output of the country since 1845. Both in total production and in the output for 1915 it ranks first among the copper-producing districts of the United States.

Copper and associated metals produced in Butte district, Montana, 1906–1915.

Year.	Copper.	Average yield in copper.	Gold.	Silver.	Year.	Copper.	Average yield in copper.	Gold.	Silver.
	Pounds.	*Per cent.*	*Ounces per ton.*	*Ounces per ton.*		*Pounds.*	*Per cent.*	*Ounces per ton.*	*Ounces per ton.*
1906.....	294,000,000	3.15	0.01	2.0	1911.....	271,200,000	3.17	0.0071	2.20
1907.....	222,000,000	2.75	.014	2.3	1912.....	308,000,000	3.02	.0065	2.09
1908.....	252,500,000	3.3	.0075	2.16	1913.....	283,600,000	2.70	.0058	1.92
1909.....	314,000,000	3.08	.0076	2.07	1914.....	235,700,000	2.66	.0059	1.83
1910.....	282,500,000	3.13	.0068	2.02	1915.....	267,000,000	2.66	.0066	1.82

The copper ores[1] of the district occur as replacement veins in a granitic rock known technically as quartz monzonite. These veins form complex systems of slightly different ages.

The principal original ore minerals in the copper veins are pyrite, enargite, bornite, chalcocite, and chalcopyrite, with varying quantities of sphalerite. It has been generally considered that the ore has resulted from the processes of enrichment and that the material produced by the original mineralization was too low in copper to be of commercial importance; but more recently many geologists have come to regard all the ore minerals in the deeper levels as of primary origin—that is, that they were deposited from ascending solutions and that only the upper parts of the deposits have been extensively affected by changes resulting from descending solutions.

The grade of ore mined in the district is regulated to a considerable degree by the possibility of profitable treatment. An increase in the price of copper or a decrease in the cost of mining and treatment permits the mining of lower-grade ores. In 1915 the average yield was 2.66 per cent of copper, the same as in 1914.

Metals produced by Anaconda Copper Mining Co. from company ores, 1913–1915.

Year.	Ore treated.	Copper.	Silver.	Gold.	Dividends.
	Short tons.	*Pounds.*	*Ounces.*	*Ounces.*	
1913	4,566,451	241,983,323	8,719,132	64,898	$12,997,500
1914	3,768,640	205,298,531	7,221,815	99,651	9,077,500
1915	4,258,129	235,076,289	8,064,986	106,702	9,325,000

[1] Weed, W. H., Geology and ore deposits of the Butte district, Mont.: U. S. Geol. Survey Prof. Paper 74, 1912. Kirk, C. T., Conditions of mineralization in the copper veins of Butte, Mont.: Econ. Geology, vol. 7, p. 35. Sales, R. H., Ore deposits at Butte, Mont.: Am. Inst. Min. Eng. Bull., August, 1913. Bard, D. C., and Gidel, M. H., Mineral associations at Butte, Mont.: Am. Inst. Min. Eng. Bull., August, 1913. Dunshee, B. H., Timbering at Butte, Mont.: Am. Inst. Min. Eng. Bull., August, 1913. Ingalls, R. W., Recent observations in Butte and Anaconda: Eng. and Min. Jour., vol. 97, pp. 937–943, 1914. Ray, J. C., Paragenesis of the ore minerals in the Butte district, Mont.: Econ. Geology, vol. 9, pp. 463–491. Laist, Frederick, Improvements at Anaconda reduction works: Min. World, vol. 42, p. 367, 1915. Mathewson, E. P., New Anaconda leaching and acid plants: Min. Jour., vol. 99, pp. 723–727, 1915. Thompson, A. P., The occurrence of covellite at Butte, Mont.: Am. Inst. Min. Eng., trans., vol. 52, pp. 563–603, 1916.

The following notes on the reduction works are taken from the annual report of the Anaconda Co.:

The reduction works treated for all companies during the year 4,421,628.69 tons of ore and other cupriferous material at Anaconda, and 384,065.56 tons of ore and other cupriferous material at Great Falls. Of this amount 4,258,129.03 tons of ore were produced by company mines, 535,223.16 tons of ore were either purchased from or treated for other companies, 12,342.06 tons of precipitates and cleanings from the old works at Anaconda were treated. At Anaconda there were produced 189,483,047 pounds of fine copper, 6,982,822.24 ounces of silver, and 75,679.668 ounces of gold; at Great Falls, there were produced 64,828,527 pounds of fine copper, 2,022,795.44 ounces of silver, and 31,023.080 ounces of gold; or a total production at both Anaconda and Great Falls of 254,311,574 pounds of fine copper, 9,005,617.68 ounces of silver, and 106,702.748 ounces of gold. Of the total production at these plants 235,076,289 pounds of fine copper, 8,064,986.02 ounces of silver, and 106,702.748 ounces of gold were produced from the mines of your company.

Extensive improvements were made to the metallurgic plants of the company in Montana, and the increased efficiency of these plants reflects great credit on the metallurgic staff.

The concentrator at Anaconda has been remodeled to permitt he application of the flotation process and its capacity increased to 15,000 tons a day. The recovery of copper in concentrates was increased from 82 to 96 per cent. A separate flotation plant with a capacity of 4,000 tons daily was erected for the treatment of current and stored slimes. The copper in the slimes is recovered at a cost of about 5 cents a pound. A recovery of 90 per cent of the copper in the stored slimes is obtained.

A leaching plant of 2,000 tons daily capacity was completed for the treatment of coarse tailings. More than 20,000,000 tons of such tailings, having a copper content of about 11 pounds to the ton, have accumulated at Anaconda. Treatment during the later part of 1915 gave an average recovery of 9.2 pounds of copper to the ton. The average cost of producing copper from the tailings is considerably less than the average cost of copper produced by the company.

A 100-ton sulphuric acid plant was erected to supply acid for the flotation and leaching plants and for other uses. It was planned to increase the capacity of this plant to 150 tons daily.

Eight reverberatory furnaces were rebuilt for firing with pulverized coal, which reduced the cost of smelting by about 50 cents a ton.

It is planned to discontinue the concentrator at Great Falls. The smelting plant will be remodeled for the treatment of concentrates from the Anaconda mill.

An electrolytic refinery, with an annual capacity of 180,000,000 pounds of refined copper, was nearly completed in 1915 and placed in operation early in 1916. An initial plant for the production of electrolytic zinc from the ores of the company was completed in 1915. It is expected that the zinc output will add very largely to the revenues of the company.

The developments in the mines are reported by the company to show highly satisfactory results, particularly on the lowest levels yet opened, where the ore bodies encountered show, on the whole, no diminution in size or in metal content and in many mines, especially the Diamond and Mountain Consolidated, show increased size and value.

The profits of the Anaconda Copper Co. for 1915 amounted to $16,695,806.

Metals produced by North Butte Mining Co., 1912–1915.

Year.	Ore and precipitates treated.	Copper.	Silver.	Gold.	Dividends.
	Short tons.	*Pounds.*	*Ounces.*	*Ounces.*	
1912	425,297	26,480,123	1,377,468	1,367	$697,000
1913	455,029	28,318,321	1,602,163	1,567	820,000
1914	337,415	18,421,761	1,092,300	1,107	635,000
1915	378,161	19,235,285	940,631	1,121	387,000

General Manager John D. Pope sums up the developments for 1915 as follows:

The important developments during the year were in the Sioux Chief vein on the 700 level, the Berlin vein on the 2,200 level, the Edith May vein on the 2,800 and 3,000 levels, and the Jessie vein on the 2,800 level. The Sioux Chief vein promises to furnish a large amount of good-grade ore from the upper levels, and the Edith May and Jessie veins have shown high-grade ore in the bottom levels.

Copper produced by East Butte Copper Mining Co., 1912–1915.

Year.	Ore mined.	Average copper content.	Copper produced by smelter.	Average cost per pound of copper.
	Short tons.	*Per cent.*	*Pounds.*	*Cents.*
1912	99,458	5.78	14,709,460	9.698
1913	105,071	5.16	14,401,108	11.040
1914	72,853	4.72	9,175,578	11.110
1915	150,911	4.28	12,542,058	11.853

Mining operations were resumed April 15, 1915, and smelting May 15, after the shutdown occasioned by the European war. During the period of shutdown the smelting plant was remodeled and its capacity increased 50 per cent. An 800-ton flotation plant was also installed for the treatment of tailings and slimes from the concentrator.

NEW MEXICO.

The production of blister copper from New Mexico in 1915 was 62,817,234 pounds, compared with 64,204,703 pounds in 1914.

Production of copper from New Mexico began in the last years of the eighteenth century, native copper from the mines of Grant County being carried to Mexico City and coined into money. During the nineteenth century, however, there was but small output. A little copper is reported for about the year 1860, but New Mexico did not have a steady output until after 1880 and did not become an important factor in production until 1900.

From 1845 to 1915 New Mexico had a recorded output of 301,572,781 pounds of copper, or 1.41 per cent of the total output of the country. The principal producing districts are those of Grant County.

Santa Rita district.—The Santa Rita district was probably the first district in the West in which there was any notable production of copper; the output began in the closing years of the eighteenth century, and the metal went to Mexico for coinage. There are no

accurate records of the production for this early period of operation, but from the best sources available it is estimated that the total production to the end of 1915 has been 298,911,000 pounds.

Copper produced in Santa Rita district, N. Mex., 1906–1915.

	Pounds.		Pounds.		Pounds.
1906	3,075,000	1910	2,670,000	1914	54,000,000
1907	5,000,000	1911	1,400,000	1915	65,000,000
1908	4,000,000	1912	25,000,000		
1909	3,300,000	1913	50,511,000		

The geology [1] of the district is rather complex. The sedimentary series, consisting of quartzite, shales, and limestones, has been invaded in post-Cretaceous time by granular and porphyritic rocks of monzonitic composition. After a period of erosion the area was buried beneath Tertiary volcanic flows, which in turn have been largely removed by erosion.

The copper deposits may be divided into two types—contact deposits and disseminated deposits. The contact deposits occur as replacements of limestone near the porphyry contact and have been most extensively worked in the Hanover end of the district. In the disseminated deposits the ore minerals occur as small veins and grains in shattered and highly altered limestones, quartzites, shales, and intrusive rocks. Much of the copper occurs native and as the oxide, though chalcocite ores are also abundant. Prior to 1912 the main production came from shallow workings, following high-grade streaks of native copper, and from oxide and chalcocite ores.

Since 1909 the Chino Copper Co. has been actively developing the main mineralized area by means of churn drills, and production by this company began late in 1911.

Metals produced by Chino Copper Co., 1911–1915.

Year.	Ore milled.	Copper content.	Mill recovery.	Production of refined copper.	Gold and silver per ton.	Cost of copper per pound.	Dividends.
	Short tons.	*Per cent.*	*Per cent.*	*Pounds.*	*Cents.*	*Cents.*	
1911				986,375			
1912	1,120,375	2.077	61.63	27,776,088		7.69	
1913	1,942,700	2.033	67.31	50,511,661		8.78	$1,919,070
1914	1,907,300	2.115	67.858	53,999,928	2.71	7.60	2,169,065
1915	2,379,800	2.155	66.588	64,887,788	3.35	7.12	2,609,860

Development during the year added to the ore reserves a quantity fully equal to the ore extracted. The company reports reserves at the end of the year of 90,000,000 tons averaging 1.75 per cent copper.

The net profits for the year were $6,913,983.87.

Ore and concentrates are treated at the El Paso and Hayden smelters. The district is served by a branch line of the Santa Fe Railway, which connects with the main line and with the Southern Pacific at Deming.

[1] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., Ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 305, 1910. Paige, Sidney, The geologic and structural relations at Santa Rita (Chino), N. Mex.: Econ. Geology, vol. 7, p. 547, 1912.

Burro Mountain district.—The Burro Mountain district, southwest of Silver City, produced about 1,400,000 pounds of copper in 1915. The total production from the district has probably been about 11,400,000 pounds.

The copper deposits[1] of the Burro Mountains occur in a fractured quartz monzonite porphyry which intrudes pre-Cambrian granite. The ores, principally chalocite, are due to downward enrichment of primary cupriferous pyrite and are found both in the porphyry and in the granite near the porphyry contact. The ore bodies are limited to areas of strong fracture and occur both in veins and as disseminated impregnations.

During 1915 operations of the Burro Mountain Copper Co. have been confined largely to developing ore and building a 1,000-ton concentrator. Mining operations were contemplated for the early part of 1916.

Production during the year from mill tests and miscellaneous sources amounted to 1,354,377 pounds of copper and 1,974 ounces of silver. Ore reserves were reported December 31, 1915, as 2,555,000 tons, averaging 2.53 per cent copper, or about 130,000,000 pounds of copper.

Lordsburg district.—The Lordsburg district, in central Grant County, has been a steady producer of copper for several years.

Copper produced in Lordsburg district, New Mexico, 1906–1915.

	Pounds.		Pounds.		Pounds.
1906	210,000	1910	1,600,000	1914	2,614,000
1907	460,000	1911	2,400,000	1915	3,890,000
1908	250,000	1912	3,000,000		
1909	589,000	1913	1,600,000		

The ore deposits[2] are fissure veins cutting dioritic and andesitic rocks.

NEVADA.

The production of blister copper in Nevada in 1915 was 67,757,322 pounds, compared with 60,122,904 pounds in 1914.

The earliest recorded production of copper in Nevada was in 1873, but the State did not become an important factor in the copper industry until 1908, when production from the Ely district began. To the end of 1915 Nevada has a recorded production of 500,003,774 pounds, or 2.34 per cent of the output of the country since 1845. To this should probably be added a small but unknown quantity of copper produced as bluestone in the early days of mining in the State and used locally in the treatment of gold and silver ores. In total production and in the output for 1915 Nevada ranks sixth among the copper-producing States.

A large part of the output has come from two districts—the Ely district, in White Pine County, and the Yerington district, in Lyon County.

[1] Lindgren, Waldemar, Graton, L. C., and Gordon, C. H., Ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 321, 1910. Paige, Sidney, Metalliferous ore deposits near the Burro Mountains, Grant County, N. Mex.: U. S. Geol. Survey Bull. 470, p. 131, 1911. Somers, R. E., Geology of the Burro Mountains copper district, N. Mex.: Am. Inst. Min. Eng. Trans., vol. 52, pp. 604–644, 1916. The note on the occurrence of the ore is furnished by Sidney Paige, who has in preparation a detailed report on the district.

[2] Lindgren, Waldemar, Graton, L. C., Gordon, C. H., Ore deposits of New Mexico: U. S. Geol. Survey Prof. Paper 68, p. 332, 1910.

Ely district.—The Ely district, White Pine County, had the largest production of copper in Nevada in 1915. Although it has long been known that the district contained copper deposits, production did not begin until 1908, when the Steptoe Valley smelter and concentrating plant was completed.

Metals produced in Ely district, Nevada, 1908–1915.

Year.	Ore.	Copper in concentrates.	Average yield in copper.	Gold and silver per ton of ore.
	Short tons.	*Pounds.*	*Per cent.*	*Cents.*
1908	429,925	14,776,363	1.72	24
1909	1,671,225	51,700,000	1.72	24
1910	2,346,354	62,332,419	1.30	21
1911	2,745,524	65,262,796	1.19	17
1912	2,985,217	64,932,446	1.09	17
1913	3,419,178	69,950,850	1.02	13.4
1914	2,749,913	51,089,921	.93	16
1915	3,172,355	64,638,158	1.02	19

To the end of 1915 the output has been about 441,060,000 pounds. The district has yielded 2.06 per cent of the total putput of the country since 1845, and it produced 4.34 per cent of the output in 1915. In total production it ranks ninth and in the production for 1915 eighth among the copper districts of the country.

The district is in the Egan Range, the geology[1] of which may be summarized as follows: Paleozoic limestones and shales have been invaded by a granitic intrusive technically known as quartz monzonite porphyry, probably of Mesozoic age. Later the area was buried beneath lava flows, which have been in large part removed by erosion.

The copper ores are of two types—replacement deposits in the limestone and disseminated deposits in the altered monzonite porphyry. The deposits in the limestone are near the quartz monzonite and are associated with garnet and other contact silicates and usually with abundant jasperoid. The deposits of this type thus far developed have been largely oxidized and the production from them has been relatively small. The disseminated ores are principally included in the monzonite porphyry area, though they extend into the adjacent sediments. The monzonite porphyry has been much shattered and altered, the hornblende and feldspars of the monzonite being altered to orthoclase, quartz, sericite, and brown mica. The metallic minerals of the primary ore, pyrite and chalcopyrite, occur as veinlets and disseminated grains in the altered rock. The ore has resulted from the process of enrichment; some of the copper in the upper part of the deposit has been taken into solution and redeposited on the sulphides lower in the deposit, usually as chalcocite. The ore consists of grains of pyrite and chalcopyrite partly or entirely replaced by chalcocite. The leached capping is of varying thickness, but for

[1] Lawson, A. C., California Univ. Dept. Geology Bull. 4, p. 284, 1906; Spencer, A. C., U. S. Geol. Survey Bull. 529, p. 189, 1913. Spencer, A. C., the geology and ore deposits of Ely, Nev.: U. S. Geol. Survey Prof. Paper 96 (in press).

a part of the deposit it is thin enough to permit its removal and the mining of the ores by steam shovel; for the remainder underground methods of mining are necessary.

At the end of 1914 for the Eureka section of the Nevada Consolidated Copper Co.'s area the average thickness of the capping was 87.1 feet and of the ore 190 feet; for the Hecla area the capping was of an average thickness of 101.4 feet and the ore 280.3 feet; and for the Liberty area the capping was 154.7 feet thick and the ore 193.3 feet.

Metals produced by Nevada Consolidated Copper Co., 1909–1915.

Year.	Ore treated.	Average assay of copper.	Average extraction of copper.	Gold and silver recovered per ton.	Copper produced.	Average cost of copper per pound.	Dividends.
	Short tons.	*Per cent.*	*Per cent.*	*Cents.*	*Pounds.*	*Cents.*	
1909 [a]	[b] 1,065,385	2.34	70.73	23.12	34,527,823	7.14	.....
1910 [c]	[b] 2,237,028	2.06	69.59	21.14	60,513,009	7.37	$2,982,644
1911 [d]	3,338,242	1.80	67.59	17.35	78,541,270	7.17	3,746,895
1912	2,852,515	1.692	68.25	16.48	63,063,261	8.86	2,999,137
1913	3,139,137	1.599	68.52	12.32	64,972,829	9.99	2,999,185
1914	2,640,294	1.483	68.48	13.45	49,244,056	10.16	2,249,389
1915	3,081,520	1.54	70.18	18.56	62,726,651	8.67	2,999,185

[a] Year to Sept. 30, 1909.
[b] Steptoe Valley Smelting & Mining Co.
[c] Year to Sept. 30, 1910.
[d] Sept. 30, 1910, to Dec. 31, 1911, inclusive.

The ore in reserve December 31, 1915, is estimated as 50,525,289 tons, having an average copper content of 1.652 per cent.

Sulphide copper ore mined and shipped to concentrator by Nevada Consolidated Copper Co., 1915.

	Quantity (short tons).	Percentage of copper.
Eureka pit	432,600	1.52
Liberty-Hecla pits	2,559,182	1.52
Ruth mine	86,029	2.28
	3,077,811	1.54

Siliceous carbonate ores amounting to 26,258 dry tons and averaging 3.48 per cent copper were mined, all of which were crushed and delivered to the smelter.

Operations of Nevada Consolidated Copper Co. concentrator, 1915.

Ore treated (dry)	short tons	3,081,520
Average copper assay	per cent	1.54
Percentage of extraction (copper)	do	70.18
Ratio of concentration		7.18
Average value in gold	ounce	.017
Average value in silver	do	.042
Percentage of extraction (gold)	per cent	49.47
Percentage of extraction (silver)	do	51.34
Average gold and silver recovered per ton of ore	cents	18.56
Average copper in concentrates	per cent	7.77

In May, 1913, the Consolidated Coppermines Co. was formed as a consolidation of several properties, including the old Coppermines Co. the Giroux, Butte Ely, and New Ely Central companies.

From May 1, 1914, to April 30, 1915, the Giroux Co. mined and shipped 107,424 wet tons of ore, and during the same period produced 1,823,641 pounds of copper, 1,449 ounces silver, and 587 ounces gold. The general manager, under date of June 1, 1915, estimates the following ore reserves:

Giroux.—Fully developed, 16,952,898 tons, averaging 1.19 per cent copper; partly developed, 7,437,108 tons, averaging 1.01 per cent copper.

Old Coppermines.—Partly developed, 1,011,304 tons, avergaing 1.02 per cent copper; total developed and partly developed, 25,401,309 tons, averaging 1.13 per cent copper.

Yerington district.—The Yerington or Mason district is in Lyon County, 50 miles southeast of Reno. It includes the productive portion of the Singatse Range, a low desert range lying between Mason Valley on the east and Smith Valley on the west.

The district did not commence to produce on a large scale prior to 1912.

Copper produced in Yerington district, Nevada, 1912–1915.

	Pounds.		Pounds.
1912	14,700,000	1914	7,480,000
1913	14,400,000	1915	700,000

The oldest rocks [1] of the district consist of andesites, felsites (soda rhyolites resembling cherts and fine-grained quartzites), and limestone, with subordinate shale, quartzite, and gypsum. They are of Triassic age and form a narrow belt extending across the Singatse Range. They were intruded in post-Triassic time, probably during the early part of the Cretaceous, by a medium-grained granodiorite, which was followed by quartz monzonite, a coarsely granular rock, which is somewhat porphyritic from the presence of large imperfect crystals of orthoclase. These intrusions intensely metamorphosed the rocks they invaded and converted large areas of them into lime-silicate rocks, among which heavy, dense brown garnetites predominate. After this metamorphism the region was cut by numerous dikes of quartz monzonite porphyry. Faulting then ensued, breaking and displacing the dikes, and along the faults ore-forming solutions rose and produced the copper deposits to which the district owes its economic importance. In Tertiary time a thick series of volcanic rocks was erupted, consisting of dacites (or quartz latites) followed by rhyolites and andesites and capped by basalt.

The principal ore bodies consist of pyrite and chalcopyrite in a gangue of pyroxene, garnet, and epidote. They are replacement deposits of limestone developed along fault zones and are of the contact-metamorphic type. The primary ore is essentially unenriched by later sulphides, secondary covellite, and chalcocite being on the whole of minor importance. The bulk of the production has come from ore bodies of this kind, and the average tenor of the ore mined has ranged from 2.75 to 5 per cent copper. Among the representatives of this group are those of the Mason Valley, Ludwig, Douglas Hill, Casting Copper, and McConnell mines; the Bluestone ore body, which belongs to the same type, has not yet produced ore

[1] This summary of the geology is written by Adolph Knopf, of the United States Geological Survey. A detailed report on the district is in preparation by Mr. Knopf.

commercially. Other types of ore deposits are sparingly represented in the district and are of subordinate economic importance. These are exemplified by the irregular bodies of rich cuprite ore in quartz monzonite porphyry at the Empire-Nevada mine and by the fissure veins in quartz monzonite and quartz monzonite porphyry, as at the Montana-Yerington mine.

The smelter of the Mason Valley Mines Co., Wabuska, was idle in 1915. At the end of the year the Nevada-Douglas Consolidated Copper Co. reported the practical completion of its mill, which is designed to employ a leaching process.

TENNESSEE.

The production of blister copper in Tennessee in 1915 was 18,205,308 pounds, compared with 18,661,112 pounds in 1914.

The entire output came from the Ducktown district, in the extreme southeastern part of the State, in Polk County. The district was one of the earliest large producers in the country. Operations began about 1850, and from that date till the end of the Civil War there was a large production from the "black-copper" ores. With the exhaustion of the rich secondary deposits attempts were made to work the lean original sulphides. These efforts met with only indifferent success, and in the late seventies the smelters shut down, thus ending the first period of activity in this district. The present period of activity began in 1890, when the Ducktown Sulphur, Copper & Iron Co. began operations. Since that time the district has been a steady producer from the primary sulphide ores. To the end of 1915 the total output of the district has been 305,410,000 pounds.

The ores [1] occur as steeply dipping lenses replacing calcareous strata in schist, and the ore bodies in general conform to the dip and strike of the schistosity of the inclosing rock. The principal sulphide is pyrrhotite, with subordinate pyrite, chalcopyrite, and sphalerite. Extensive gossans capped the ore bodies, and it was the enriched zones underlying these that furnished the rich chalcocite ores extracted during the first period of activity.

Metals produced in Ducktown district, Tenn., 1906–1915.

Year.	Ore treated.	Copper produced.	Average yield of copper.	Gold and silver per ton of ore.
	Short tons.	*Pounds.*	*Per cent.*	*Cents.*
1906	538,141	17,809,442	1.7	8
1907	558,487	19,475,119	1.77	7
1908	618,806	19,710,103	1.55	5
1909	576,680	19,207,747	1.66	6
1910	552,796	16,691,777	1.52	8
1911	581,974	18,965,143	1.62	11.7
1912	603,229	18,395,256	1.53	10.5
1913	652,253	19,489,654	1.476	11.2
1914	653,621	18,661,112	1.435	9
1915	623,534	18,205,308	1.45	.....

[1] Heinrich, Carl, Am. Inst. Min. Eng. Trans., vol. 25, p. 173, 1895. Weed, W. H., idem, vol. 30, p. 452; 1900. Kemp, J. F., idem, vol. 31, p. 224, 1900. Higgins, E., Eng. and Min. Jour., vol. 86, pp. 1237–1241, 1908. Channing, J. P., Min. and Sci. Press, vol. 96, p. 97, 1908. Gottsberger, B. B., Min. World, vol. 29, pp. 911–914, 1908. Weed, W. H., Ore deposits of the Appalachian States: U. S. Geol. Survey Bull. 455, p. 152, 1911. Laney, F. B., The manufacture of sulphuric acid from smelter fumes at Ducktown, Tenn.: U. S. Geol. Survey Mineral Resources, 1911, pt. 2, p. 958, 1912. Emmons, W. H., and Laney, F. B., Preliminary report on the mineral deposits of Ducktown, Tenn.: U. S. Geol. Survey Bull. 470, pp. 151–152, 1911.

A part of the copper is marketed without refining, and the gold and silver contained are not recovered. This accounts in large part for the variation in the gold and silver recovered per ton of ore treated.

The fact that the ores can be extracted with little timbering, the cheap supply of coke and coal from Tennessee and West Virginia, and the comparatively low cost of labor have made it possible to mine and treat these low-grade ores at a profit.

The pyritic process of smelting is practiced successfully by both the Ducktown Sulphur, Copper & Iron Co. and the Tennessee Copper Co. The low-grade matte produced by the first smelting is resmelted and brought to a proper grade for conversion.

Sulphuric-acid plants were operated by both companies. The successful operation of these plants has not only solved the troublesome smelter-smoke problem but added very materially to the revenue of the companies. The production of sulphuric acid will probably be fully as important in the future as the output of copper.

Copper and acid produced by Tennessee Copper Co., 1911–1915.

Year.	Ore smelted.	Copper.	Sulphuric acid, 60° Baumé.	Cost of copper per pound.	Dividends.
	Short tons.	*Pounds.*	*Short tons.*	*Cents.*	
1911	436,285	13,808,940	.....	10.88	$300,000
1912	444,289	13,252,634	192,084	11.00	500,000
1913	470,135	13,493,140	197,712	11.34	750,000
1914	485,051	12,871,113	210,163	11.84	600,000
1915	475,301	12,750,418	210,666	10.53	600,000

The total dividends declared by the Tennessee Copper Co. to the end of 1915 amounted to $5,056,250. The company's reserves of ore in the Burra Burra, London, and Polk County mines at the end of 1915 were estimated at 3,707,421 tons.

Copper and acid produced by Ducktown Sulphur, Copper & Iron Co., 1913–1915.

Year.	Ore treated.	Copper.	Sulphuric acid, 60° Baumé.
	Short tons.	*Pounds.*	*Short tons.*
1913	182,000	5,992,000	.....
1914	169,000	5,862,000	45,770
1915	150,400	5,370,000	41,295

The Ducktown Co. estimates that its ore reserves at the Mary mine amount to 1,000,000 tons, averaging not less than 2 per cent copper and 17 per cent sulphur. The East Tennessee mine is reported as capable of producing 30,000 tons of ore, averaging in excess of 2½ per cent copper and 8 per cent sulphur. The Isabella mine has reserves of 2,500,000 tons, averaging 29 per cent sulphur and 0.8 per cent copper.

The district is served by a branch line of the Louisville & Nashville Railroad, with which the mines and smelters of the companies are connected by private line.

UTAH.

In 1915 Utah produced 175,177,695 pounds of blister copper, compared with 160,589,660 pounds in 1914.

The first recorded production of copper from Utah was in 1870, but the State did not become a large copper producer until about 1900. Since that time the growth of the industry has been steady and rapid. The total recorded output from the State to the end of 1915 has been 1,417,395,645 pounds, or 6.63 per cent of the output of the United States since 1845. In 1915 Utah produced 12.62 per cent of the output. In total output and in the production for 1915 it ranks fourth among the copper-producing States.

Two copper-smelting plants were operated in the State during 1915—the Garfield smelter, at Garfield, and the International smelter, at Tooele.

Bingham district.—The presence of copper minerals in the Bingham district has been known since the early days of mining in the district, but for many years operations were confined to the production of lead, silver, and gold, and not until 1896 did the mining of copper ore become of commercial importance. To the end of 1915 the district has produced approximately 1,149,500,000 pounds of copper, or 5.37 per cent of the output of the country since 1845. For 1915 the district yielded 11.09 per cent of the total production. In total output the district ranks fifth among those of the country, and in the production for 1915 it ranks third.

Copper produced in Bingham district, Utah, 1906–1915.

	Pounds.		Pounds.		Pounds.
1906	39,000,000	1910	112,000,000	1914	150,000,000
1907	47,000,000	1911	125,000,000	1915	165,000,000
1908	56,000,000	1912	112,000,000		
1909	86,000,000	1913	132,000,000		

The ore deposits of the district [1] are closely associated with masses of monzoonite porphyry intruded into a series of quartzites with intercalated beds of limestone and shale of Carboniferous age. The copper ores are of two types of occurrence—irregular replacement deposits in limestone and disseminated deposits in altered porphyry and quartzite.

In the early years of production most of the copper from the district was derived from the replacement deposits in limestone. These are massive bodies of pyrite carrying chalcopyrite in varying quantity and in places grading into ores that contain considerable galena and sphalerite. They occur as replacements of the limestone associated with fissures and usually not far from bodies of monzonite porphyry. Enrichment has not extended to great depth in deposits of this type, and the enriched ores have been largely extracted. The ores vary greatly in copper content, and consequently the average percentage derived for a given year depends largely on the grade that can be worked at a profit at the current price of copper. In 1915 the ores yielded about 2.10 per cent of copper and had a rather high content

[1] For detailed information see Boutwell, J. M., Economic geology of the Bingham mining district, Utah: U. S. Geol. Survey Prof. Paper 38, 1905. Beeson, J. J., The disseminated copper ores of Bingham Canyon, Utah: Am. Inst. Min. Eng. Bull. 107, pp. 2191–2236, 1916.

of gold and silver. About 393,000 tons of ore of this type were produced during the year, and yielded about 16,500,000 pounds of copper.

The primary minerals of the disseminated ore consist of grains and veinlets of pyrite and chalcopyrite disseminated through shattered and altered monzonite porphyry and quartzite. The varying intensity of alteration of the monzite porphyry has yielded different gangue minerals in different parts of the disseminated ore body, forming what is designated as "dark porphyry" and "light porphyry."

In the "dark porphyry" the hornblende and augite of the monzonite have been altered to brown mica, and the plagioclase feldspar has been altered in part to sericite and in part to secondary orthoclase. The abundant brown mica gives the rock a dark color. In the "light porphyry" the lime and magnesia have been largely removed and there has been a marked addition of potassium, resulting in a rock composed essentially of quartz, secondary orthoclase, and sericite, together with the metallic sulphides.

The ore is the result of enrichment, the copper content of the upper portion of the deposit having been in part taken into solution and redeposited on the sulphides at greater depth. These secondary sulphides include both covellite and chalcocite. As contrasted with many similar deposits covellite is relatively abundant as a secondary sulphide. Secondary sulphides are relatively less abundant in the Bingham disseminated ores than in several similar deposits. The ore body is an irregular layer covered by the leached and partly leached "capping" and underlain by the lean primary material. The average thickness of the ore, as shown by the developments of the Utah Copper Co. to the end of 1915, is 480 feet. The thickness of the "capping" varies greatly at different points. As determined at the end of 1914, the average thickness over the entire ore body is 115 feet. The desseminated ores have been extracted by both steam-shovel and underground methods. Underground methods have, however, been practically discontinued. During the year about 8,900,000 tons of disseminated ore was mined and concentrated in the district. The ore yielded about 0.875 per cent of copper in concentrates and small amounts per ton in gold and silver.

The ores were treated at the mills at Garfield and at the Ohio Copper Co.'s mill at Lark. The ores and concentrates from the district were reduced at the Garfield and International smelters.

Metals produced by Utah Copper Co., 1911–1915.

Year.	Ore milled.	Copper content.	Mill recovery.	Refined copper.	Gold and silver per pound of copper	Cost per pound of copper.	Dividends.
	Short tons.	*Per cent.*	*Per cent.*	*Pounds.*	*Cents.*	*Cents.*	
1911	4,680,801	1.51	69.53	93,514,419	1.07	7.865	$4,703,022
1912	5,315,321	1.36	66.32	91,366,337	.95	9.024	4,729,747
1913	7,519,392	1.25	63.95	113,942,834	.64	9.498	4,747,710
1914	6,470,166	1.42	66.04	115,690,445	.75	8.131	4,827,885
1915	8,494,300	1.43	64.13	148,397,006	.62	7.56	6,904,082

The profits of the Utah Copper Co. for 1915 were $17,913,481.

At the end of 1915 development had been carried on over an area of 226.3 acres and ore estimated at 390,000,000 tons, having an average copper content of 1.447 per cent, had been developed and partly developed. Of this ore 43,684,700 tons, having an average copper content of 1.453 per cent, had been extracted prior to January 1, 1916, leaving ore reserves at that date of 346,315,300 tons, averaging 1.446 per cent copper.

The mills at Garfield are capable of treating 24,000 tons of ore daily.

Copper and associated metals produced by Utah Consolidated Mining Co., 1911–1915.

Year.	Ore.	Copper content.	Gold per ton.	Silver per ton.	Copper.[a]	Dividends.
	Short tons.	*Per cent.*	*Ounce.*	*Ounce.*	*Pounds.*	
1911	162,522	2.891	0.0936	0.9815	9,162,023	$150,000
1912	159,143	2.146	.077	.828	6,506,814	450,000
1913	181,077	1.987	.056	.705	7,710,668	450,000
1914	153,345	2.509	.085	.996	7,584,391	600,000
1915	207,119	2.22	.075	1.02	8,836,091	600,000

[a] Includes copper derived from lead ores.

In recent years the Utah Consolidated Co. has been a large producer of lead ores, the yield in 1915 being 17,777,604 pounds. At the end of the year there was "in sight" in the mine 266,700 tons of copper ore, averaging 1.90 per cent copper and 0.05 ounce gold and 0.69 ounce silver per ton. The ore was shipped by aerial tram to the International smelter.

Several other mines in the district yielded considerable quantities of copper and copper-lead ores, notably the Old Jordan mine of the United States Mining Co., the Yampa mine, the Bingham-New Haven mine, and the mines of the Bingham Mines Co.

The district is served by a branch of the Denver & Rio Grande Railroad and by the Bingham & Garfield Railway, controlled by Utah Copper Co. interests, which connects the mines at Bingham with the mills at Garfield. Cable tramways are employed to considerable extent; the ores from the Utah Consolidated mines are delivered to the International smelter in this manner, and ores from other mines are delivered to the railroad over cable tramways.

Tintic district.—The production of copper from the Tintic district is largely incidental to the production of other metals. The quantity of ore in which copper is the most valuable metal constituent is relatively small. There has been a small output of copper from the district for many years, but no accurate statistics of the early output are available. It is estimated that to the end of 1915 the district has yielded 124,500,000 pounds of copper.

Copper produced in Tintic district, Utah, 1906–1915.

	Pounds.		Pounds.		Pounds.
1906	7,300,000	1910	9,000,000	1914	6,000,000
1907	7,800,000	1911	10,900,000	1915	5,350,000
1908	5,700,000	1912	13,000,000		
1909	6,000,000	1913	9,250,000		

The occurrence of ores [1] may be briefly summarized as follows:

The sedimentary series, consisting of limestone and quartzite, has been intruded by an extensive mass of monzonite. The ores occur as replacement deposits in the limestone near the monzonite contact, as replacement veins in the igneous rocks, and as replacement veins in the sedimentary series. The most valuable deposits developed are of the last-named type. The fissures are as a rule nearly vertical, and the replacement bodies are extremely irregular in form and variable in size. The original minerals were pyrite, galena, sphalerite, and enargite, with rich silver and gold minerals in a gangue of quartz and barite.

There has been little development below the water level, which is usually below 1,600 feet in the deposits in limestone, and oxidation to this point has been rather complete. Recent developments below the water level in some of the mines have been encouraging.

The Centennial-Eureka mine has been the largest producer of copper. During the year it was reported that bodies of high-grade copper ore had been developed in the Iron Blossom mine.

Beaver County.—The first notable production of copper from Beaver County came from the Horn Silver mine in 1889, and since that time copper has been produced from lead-silver ores and from small copper mines. The importance of the district as a copper camp dates from the starting of the mill in 1905 to treat ores of the Cactus mine. To the end of 1915 the district has yielded about 40,500,000 pounds of copper.

Copper produced in Beaver County, Utah, 1906–1915.

	Pounds.		Pounds.		Pounds.
1906	5,400,000	1910	1,100,000	1914	1,500,000
1907	4,900,000	1911	3,600,000	1915	425,000
1908	5,500,000	1912	3,000,000		
1909	1,200,000	1913	3,000,000		

The largest output has been from the Cactus mine; other producers are the Horn Silver, O K, Old Hickory, and other mines.

The ores [2] of the area are of several types. Those of the Cactus mine consist of pyrite and chalcopyrite disseminated in an area of highly brecciated and altered quartz monzonite. Most of the ore is of low grade and requires concentration before shipping.

The ores of the Old Hickory mine are of the contact type. They are high in iron, which adds to their value.

During 1915 a flotation plant was installed for the treatment of tailings from the Cactus mill.

Lucin district.—The Lucin district, in Boxelder County, has been an intermittent producer of copper for several years. The main output has been from the Copper Mountain mine. The ores occur as a replacement of limestone and, so far as developed, are oxidized.

Tutsagubet district.—The Tutsagubet district, in Washington County, has yielded over 10,000,000 pounds of copper, but has not been active for several years. The largest deposit, that of the Dixie

[1] For detailed report, see Tower, G. W., and Smith, G. O., U. S. Geol. Survey Nineteenth Ann. Rept., pt. 3, pp. 601–767, 1899. A report on the district by Waldemar Lindgren and G. F. Loughlin is in preparation for publication.

[2] For detailed description of the ore deposits, see Butler, B. S., Geology and ore deposits of the San Francisco and adjacent districts, Utah: U. S. Geol. Survey Prof. Paper 80, 1913.

mine, occurs as a replacement of limestone. The ores thus far extracted have been oxidized.

Other districts.—Considerable copper has been produced in the Park City, Big Cottonwood, Little Cottonwood, Ophir, and Rush Valley districts, where the metals of chief value are lead and silver.

OTHER STATES.

New Hampshire.—New Hampshire has produced little copper in recent years. The largest producer has been the Milan mine, Coos County. The ores,[1] which consist mainly of pyrite, chalcopyrite, and zinc blende, with small quantities of other sulphides, occur as lenses in schist. Much of the ore is treated for acid manufacture, and the copper is recovered from the resulting "cinders."

North Carolina.—North Carolina produced 33,383 pounds of blister copper in 1915, compared with 19,712 pounds in 1914. The largest producing district of the State has been the Virgilina district in Granville and Person counties. The deposits [2] occur as fissure veins in schist that has been invaded by granitic intrusives, and the ore veins are thought to be closely related to the intrusive rocks. The ore minerals are bornite and chalocite in a gangue of quartz, with subordinate carbonate and epidote. The chalcocite is thought to be in part a primary mineral.

The Gold Hill district has in recent years produced some copper. The deposits [3] consist of rather narrow stringers or veins of auriferous pyrite and chalcopyrite in a quartz gangue in schist.

A small production has been made from the Cullowhee district, Jackson County. The deposits [4] occur as poorly defined veins in schist. The principal ore minerals are pyrrhotite and chalcopyrite.

Oregon.—Oregon produced 797,471 pounds of blister copper in 1915, compared with 5,599 pounds in 1914. To the end of 1915 the State has a recorded output of 3,768,469 pounds of copper. The largest production in recent years has come from the Waldo district, in Grant County. A smelting plant at Takilma has been operated for short periods at irregular intervals.

The deposits [5] occur as bodies of pyrite with subordinate chalcopyrite and bornite, in quartz porphyry near its contact with slate, and as bodies of pyrrhotite and chalcopyrite in greenstone or serpentine near a contact with other rocks.

Pennsylvania.—In recent years there has been a small production of copper from the iron mines of Lebanon County. These ores [6] carry a small quantity of pyrite and chalcopyrite, which is separated by magnetic dressing of the iron ores. The sulphides are treated for their copper content.

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[1] Emmons, W. H., Some ore deposits of Maine and the Milan mine, New Hampshire: U. S. Geol. Survey Bull. 432, p. 54, 1910. Weed, W. H., Copper deposits of the Appalachian States: U. S. Geol. Survey Bull. 455, p. 18, 1911.

[2] Laney, F. B., The relation of bornite and chalcocite in the copper ores of the Virgilina district of North Carolina and Virginia: U. S. Nat. Mus. Proc., vol. 40, pp. 513–524. Weed, W. H., op. cit., p. 67.

[3] Laney, F. B., The Gold Hill mining district: North Carolina Geol. and Econ. Survey Bull. 21, p. 83, 1910. Weed, W. H., op. cit., p. 140.

[4] Weed, W. H., op. cit., p. 138.

[5] Diller, J. S., Mineral resources of southwestern Oregon: U. S. Geol. Survey Bull. 546, p. 72, 1914. Diller, J. S., and Kay, G. F., Mineral resources of the Grants Pass quadrangle and bordering districts, Oreg: U. S. Geol. Survey Bull. 380, pp. 76–78, 1909.

[6] Spencer, A. C., Magnetite deposits of the Cornwall type in Berks and Lebanon counties, Pa.: U. S. Geol. Survey Bull. 315, pp. 185–189, 1907. Weed, W. H., op. cit., p. 62.

Vermont.—Vermont produced 23,995 pounds of blister copper in 1915. The most valuable deposits of the State are those near Ely, which have been worked at intervals since 1821 and have made a considerable contribution to the copper output of the country, though the production in the early years is not known. The ores[1] consist of irregular lenses of pyrite, pyrrhotite, and chalcopyrite in schistose rocks that have resulted from the metamorphism of sediments.

Virginia.—Virginia produced 50,008 pounds of blister copper in 1915, compared with 17,752 pounds in 1914.

The principal producers have been the Dumfries district, in Prince William County, and the Virgilina district. The occurrence of the ores[2] in the Virgilina district has already been mentioned under North Carolina. At Dumfries most of the copper is derived from pyritic ores carrying low values in copper. These ores are treated for the production of sulphuric acid, and the resultant "cinder" is smelted for its copper content. Some copper ore is sorted in the mining of the pyrite ore. The ores consist of lenses of pyrite with a little chalcopyrite in schist.

Other districts have been productive but have yielded little in recent years. The most important of these is the "great gossan lead," extending from Carroll County into North Carolina, in which copper was obtained from the enriched "black copper" zone underlying the gossan. The ores[3] consist of pyrrhotite with some pyrite in schist.

Washington.—Washington produced 903,661 pounds of blister copper in 1915, compared with 683,602 pounds in 1914. The State contains no important producing district, the total recorded output to the end of 1915 being only 5,563,227 pounds.

The output in 1915 was obtained mainly from the Danville district, Ferry County, and the Chewelah district, Stevens County.

The Tacoma smelter is operated principally on ores from points outside of the State. Most of the Alaska copper ore is treated at this plant.

Wyoming.—Wyoming produced 351,871 pounds of blister copper in 1915, compared with 17,082 pounds in 1914. To the end of 1915 the State has a recorded output of 26,730,167 pounds.

The Encampment district, the chief producer, has not been active for several years. Exact statistics of the output of this district are not available, but it has probably been over 20,000,000 pounds.

The most valuable deposits of the Encampment district[4] occur in a zone of brecciated quartzite underlying schist. The original ore was chalcopyrite with possibly some pyrite. Enrichment has produced bodies of chalcocite in the upper workings, but these give place to chalcopyrite at depth.

REFINERY PRODUCTION.

The refinery output of copper in the United States in 1915 was made by 13 plants, 9 of which employed the electrolytic method and 5 employed the furnace process on Lake Superior copper, the Calumet

[1] Smyth, H. L., and Smith, P. S., The copper deposits of Orange County, Vt.: Eng. and Min. Jour., vol. 77, p. 177, 1904. Weed, W. H., op. cit., p. 24.
[2] Watson, T. L., Mineral resources of Virginia, p. 494, Virginia Jamestown Exp. Comm., 1907.
[3] Watson, T. L., op. cit., p. 511. Weed, W. H., op. cit., p. 116.
[4] Spencer, A. C., Copper deposits of the Encampment district, Wyo.: U. S. Geol. Survey Prof. Paper 25, 1904.

& Hecla plant employing both methods. Six of the large electrolytic refineries are on the Atlantic tidewater, and 5 Lake refineries are on the Great Lakes. Only two plants are located west of the Great Lakes—one at Great Falls, Mont., and one at Tacoma, Wash. In addition to these refineries, there are numerous plants in different parts of the country that make a considerable output from old copper, brass, and other alloys of copper. The output of the regular refining plants is in the form of casting, Lake, and electrolytic copper.

CASTING AND PIG COPPER.

Blister copper that is low in precious metals and sufficiently free from impurities for certain uses is refined by the furnace process and ordinarily cast into ingots. This copper is usually unfit for uses requiring a high-grade copper, such as electric transmission, brass manufacture, and rolling, but is suitable for copper castings, and a large part of it is put to that use. Lake copper excepted, a comparatively small percentage of the copper output carries so small a content of precious metals that, together with the value added to the copper by electrolytic refining, it will not more than pay for the electrolytic refining of the copper; consequently the output of casting copper is small. Some blister or pig copper low in precious metals is exported without further treatment and is probably consumed without electrolytic refining. A large percentage of the casting copper shown in the table is from the Morenci-Metcalf district, Ariz. The pig copper is largely from that district, but some is from Ducktown, Tenn. Both districts produce a rather high grade of blister copper carrying a small amount of percious metals, and it is found profitable to market much of the copper from the Morenci district without electrolytic refining. During 1915 the production of new casting copper amounted to 21,555,129 pounds and of pig copper to 15,047,990 pounds.

LAKE COPPER.

By Lake copper, as the term is used in this report, it meant the output of the Lake smelters. A considerable portion of this output is refined electrolytically, but most of the electrolytically refined Lake copper is mixed with furnace-refined copper or is sold as some brand of Lake copper. Of the 238,956,410 pounds of copper produced by the Lake smelters, about 54,700,000 pounds were refined electrolytically, either to free the copper from impurities or to recover the silver content.

ELECTROLYTIC COPPER.

Under electrolytic copper, as shown in the accompanying table, is included all new copper that was refined electrolytically, except that from the Lake district that was marketed as Lake copper. In 1915 the production of electrolytic copper from primary materials of domestic origin[1] amounted to approximately 1,114,345,342 pounds and from materials of foreign origin to 246,498,925 pounds. Electrolytic copper amounting to 38,156,789 pounds was produced from secondary sources, making a total electrolytic production of 1,339,001,056 pounds for the year.

[1] The separation of refined copper into copper of domestic and foreign origin is only approximate.

SECONDARY COPPER.

Under secondary copper is considered material recovered from remelting old copper, copper scraps, and copper recovered from the treatment of copper alloys or alloys that are treated without the separation of the copper. A canvass of plants producing secondary copper has been made by J. P. Dunlop, of the United States Geological Survey. Concerning the output of secondary copper [1] Dunlop says:

The total quantity of secondary copper recovered in 1915, on the assumption that the brass remelted had an average copper content of 70 per cent, was 196,187 tons, of which 29,787 tons (13,900 tons more than in 1914), was recovered by plants refining primary metals and the remainder by plants treating only secondary materials. The copper produced by smelters of the latter class includes 54,150 tons of pig copper, 16,000 tons of copper in alloys other than brass, and 96,250 tons of copper in remelted brass. These figures indicate an increase for 1915 of about 17,500 tons of pig copper and 26,900 tons of copper in brass and of about 10,000 tons in alloys other than brass. At least 75,000 tons were recovered from clean scrap made in the course of manufacture of copper and brass ware, so that only about 121,000 tons was obtained from ashes, cinders, and scrap, or from material that had actually been used and discarded.

REFINED COPPER.

The total production of new refined copper in 1915 was 1,634,000,000 pounds, an increase of 100,000,000 pounds over the output in 1914.

Production of primary and secondary copper by the regular refining plants in 1913, 1914, and 1915, in pounds.

	1913		1914		1915	
	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Foreign.
Primary:						
Electrolytic	1,022,497,601	378,243,869	991,573,073	323,358,205	1,114,345,342	246,498,925
Lake	155,715,286	.....	158,009,748	.....	[a] 236,757,062	.....
Casting	22,606,040	.....	21,506,325	.....	21,555,129	.....
Pig	36,004,986	.....	39,334,043	.....	15,047,990	.....
Total primary	[b] 1,236,823,913	[b] 378,243,869	[b] 1,210,423,189	[b] 323,358,205	[b] 1,387,705,523	[b] 246,498,925
	1,615,067,782		1,533,781,394		1,634,204,448	
Secondary:						
Electrolytic	14,862,577		27,702,928		38,156,789	
Casting	22,360,182		4,224,052		21,417,901	
Total secondary	37,222,759		31,926,980		59,574,690	
Total output	1,652,290,541		1,565,708,374		1,693,779,138	

[a] Some Lake copper was refined at seaboard plants and doubtless marketed under some brand other than Lake. This has been excluded from the Lake copper.

[b] The distribution of refined copper of domestic and foreign origin is only approximate, as an accurate separation at this state of manufacture is not possible.

In addition to the secondary material treated by the regular refining companies, plants that treated secondary material exclusively produced a total of about 332,800,000 pounds of copper as copper and as copper in brass and in other alloys, making a total production of 392,374,000 pounds from secondary sources. Of this total at least 150,000,000 pounds was produced by remelting clean scrap produced in the process of manufacture of copper and brass articles.

[1] Dunlop, J. P., Secondary metals: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, pp. 25–26, 1916.

If the output of plants treating purely secondary material is added to the production of the regular refining companies, the contribution from plants in the United States to the world's supply of copper for 1915 is found to be 2,026,000,000 pounds.

In addition to the output of metallic copper, the regular refining companies produced bluestone with a copper content of 10,621,000 pounds.

Refined copper produced in the United States, 1906–1915, in pounds.

Year.	From primary sources (domestic and foreign).				From secondary sources (copper and copper in alloys).
	Electrolytic.	Lake.	Casting and pig.	Total.	
1906	815,966,781	229,626,215	43,159,413	1,079,052,409	.....
1907	802,471,434	213,452,129	58,943,647	1,032,516,247	.....
1908	848,109,132	222,289,584	67,563,692	1,137,962,408	.....
1909	1,101,894,864	227,005,923	62,120,667	1,391,021,454	.....
1910	1,128,304,726	221,462,984	72,271,426	1,422,039,135	.....
1911	1,156,111,987	218,185,236	59,577,803	1,433,875,026	214,000,000
1912	1,274,935,371	231,112,228	62,056,879	1,568,104,478	275,000,000
1913	1,400,741,470	155,715,286	58,611,026	1,615,067,782	273,000,000
1914	1,314,931,288	158,009,748	60,840,368	1,533,781,394	255,764,000
1915	1,360,844,267	236,757,062	36,603,119	1,634,204,448	392,274,000

COPPER SULPHATE.

The production of hydrous copper sulphate or bluestone by the refineries of the United States in 1915 was 42,086,107 pounds, having a copper content of 10,621,524 pounds, compared with 34,411,443 pounds of bluestone, having a copper content of 8,602,861 pounds, in 1914.

STOCKS.

Stocks of copper Jan. 1 each year, 1906–1916, in pounds.

Year.	Refined copper.	Blister and material in process of refining.	Year.	Refined copper.	Blister and material in process of refining.
1906	118,224,028	110,000,144	1912	88,372,195	219,864,749
1907	46,497,181	135,310,239	1913	105,497,683	274,072,084
1908	125,745,796	175,254,659	1914	90,385,402	247,789,811
1909	121,876,759	234,013,843	1915	173,640,501	203,067,571
1910	141,486,244	266,754,808	1916	82,429,666	274,000,000
1911	122,803,656	245,218,530			

IMPORTS.

The quantity of copper in unmanufactured form imported into the United States in 1915 was 315,698,449 pounds, according to the records of the Bureau of Foreign and Domestic Commerce. The imports in 1914 were 306,350,827 pounds. The following table shows the character and source of copper-bearing materials imported during 1914 and 1915:

Copper imported into the United States in 1914 and 1915, in pounds.

Country.	Ore, matte, and regulus, copper content.		Pigs, bars, ingots, plates, old, etc.	
	1914	1915	1914	1915
United Kingdom		94,801	5,163,126	7,475,625
Germany	4,684,668			32,951
Spain	2,633,395	1,278,403	16,931,784	7,964,534
Canada	21,304,104	29,591,823	27,230,559	43,419,681
Mexico	15,495,694	14,707,724	43,193,868	17,531,986
Chile	30,562,839	33,435,039	23,814,659	36,313,505
Cuba	18,659,788	28,876,226		1,042,101
Peru		3,299,327	44,488,809	61,342,067
Japan			10,918,069	17,970,768
Australia and Tasmania		500	15,130,001	443,520
Other countries	8,460,836	3,047,598	14,678,628	7,830,270
	104,801,324	114,331,441	201,549,503	201,367,008

The copper imported as matte and blister included some copper of domestic origin that was treated in foreign plants during the year.

Copper imported into the United States, 1906–1915.

	Pounds.		Pounds.		Pounds.
1906	225,593,281	1910	344,435,771	1913	408,778,954
1907	252,620,054	1911	334,607,538	1914	306,350,827
1908	218,705,487	1912	410,241,295	1915	315,698,449
1909	321,801,114				

EXPORTS.

The exports of metallic copper from the United States in 1915 amounted to 681,917,855 pounds, according to the Bureau of Foreign and Domestic Commerce. In addition the copper content of 58,231 long tons of ore, matte, and regulus was exported in 1915, compared with the content of 43,529 long tons in 1914.

Domestic copper (ingots, bars, plates, and old) exported from the United States in 1913, 1914, and 1915, in pounds.

Country.	1913	1914	1915
United Kingdom	133,679,641	198,382,459	201,182,655
Austria-Hungary	34,648,205	26,989,548	
Belgium	7,102,120	5,429,717	
France	160,000,345	150,839,897	236,236,135
Germany	307,150,761	176,698,948	
Italy	41,568,713	67,415,944	107,101,156
Netherlands	178,940,289	126,001,150	4,018,841
Russia in Europe	7,907,672	8,731,272	37,430,402
Other Europe	14,357,014	45,634,229	56,015,517
Canada	35,982,207	24,221,498	24,128,182
Other countries	4,904,125	9,736,260	15,804,967
	[a] 926,241,092	840,080,922	[b] 681,917,855

[a] Includes sheets, rods, wires, etc.
[b] Does not include copper content of 311,442 pounds of concentrates and 1,556 186 pounds of ore.

The copper exported was in the following forms:

Copper exported from the United States, 1915.

	Quantity (pounds).	Value.
Six months ending June, 1915.		
Ore (copper content)		
Concentrates (copper content)	311,442	$55,005
Ore, matte, and regulus		107,207
Pigs, ingots, bars	287,151,773	44,422,634
Plates and sheets	19,282,699	3,104,851
Rods and wire	36,162,542	5,609,621
All other	6,540,106	1,040,319
	349,448,562	54,339,637
Six months ending December, 1915.		
Unrefined black blister and converted copper, bars, pigs, and other forms	1,233,137	227,791
Ore (copper content)	1,556,186	290,913
Refined in ingots, bars, rods, or other forms	300,412,186	56,703,111
Old and scrap	154,560	24,561
Plates and bars	16,695,945	3,279,026
Wire	14,284,907	2,838,902
All other		7,885,472
	334,336,921	71,249,776
Grand total, 12 months	683,785,483	125,589,413

The value of the copper exported is stated by the Bureau of Foreign and Domestic Commerce as $146,377,621 in 1913, $117,633,145 in 1914, and $117,703,941 in 1915.

Metallic copper exported from the United States, 1906–1915.

	Pounds.		Pounds.		Pounds.
1906	454,752,018	1910	708,316,543	1914	840,080,922
1907	508,929,401	1911	786,553,208	1915	681,917,855
1908	661,876,127	1912	775,000,658		
1909	682,846,726	1913	926,241,092		

CONSUMPTION.

The apparent consumption of refined new copper in the United States in 1915 was about 1,043,000,000 pounds. In 1914 it was about 620,445,373 pounds. The method employed in determining the quantity of copper retained for domestic consumption is shown in the following table, which does not include stocks of copper held by consumers:

Apparent domestic consumption of refined new copper in 1912, 1913, 1914, and 1915, in pounds.

	1912	1913	1914	1915
Total refinery output of new copper	1,568,104,478	1,615,067,782	1,533,781,394	1,634,204,448
Stock at beginning of year	88,372,195	105,497,683	90,385,402	173,640,501
Total available supply	1,656,476,673	1,720,565,465	1,634,166,796	1,807,844,949
Refined copper exported	[a] 775,000,658	[a] 817,911,424	[a] 840,080,922	[a] 681,953,301
Stocks at end of year	105,497,683	90,385,402	173,640,501	82,429,666
Total withdrawn from supply	880,498,341	908,296,826	1,013,721,423	764,382,967
Apparent consumption	775,978,332	812,268,639	620,445,373	1,043,461,982

[a] Exports of pigs, ingots, bars, rods, etc., reported by the Bureau of Foreign and Domestic Commerce.

If to the 1,043,461,982 pounds of new refined copper is added the 392,274,000 pounds of secondary copper and copper in alloys produced during the year, it is found that a total of about 1,435,000,000 pounds of new and old copper was available for domestic consumption.

Domestic consumption of new copper, 1906–1915.

	Pounds.		Pounds.		Pounds.
1906	677,434,937	1910	732,405,180	1913	812,268,639
1907	487,771,625	1911	681,753,279	1914	620,445,373
1908	479,955,318	1912	755,978,332	1915	1,043,461,982
1909	688,565,243				

USES.

No systematic attempt has been made to ascertain the proportion of the copper output of 1915 used in different industries, such as electric transmission, brass manufacture, and casting, but some idea of the quantities entering the different industries can be gained from the forms in which the output of the refineries was cast. The following table shows the approximate quantity of copper cast in the different forms during 1915 as reported by the refining companies. It will be noted that the total is not the same as the refinery output for 1915.

Cast in different forms in 1915.

Form.	Quantity (pounds).	Percentage.
Wire bars	599,344,077	37
Ingots and ingot bars	731,821,039	45
Cakes	150,816,769	9
Cathodes	93,865,054	6
Other forms	56,082,773	3
	1,631,929,712	100

It may be assumed that a large portion of the 37 per cent cast as wire bars was used in the electric industry and that the 9 per cent cast as cakes was used largely for rolling. The other forms are less easily classified. The 6 per cent cast as cathodes, together with a portion of the ingots, probably entered the brass industry, and a large quantity of copper ingots was used in casting. The refinery output for 1914 was cast as follows: Wire bars, 52 per cent; ingots, 29 per cent; cakes, 10 per cent; cathodes, 7 per cent; other forms, 2 per cent. The most notable change was the relative decrease in wire bars and increase in ingots, which may roughly represent the relative increase in the consumption for brass.

The large increase in domestic consumption of copper in 1915 was undoubtedly due in large part to the manufacture of war munitions. The expansion of other industries, however, was a factor that can not be ignored. For example, the annual report of the American Telephone & Telegraph Co. for 1915 contains the following statement:

> The total mileage of wire in use for exchange and toll service was 18,505,545 miles, of which 1,029,951 were added during the year. These figures do not include the mileage of wire operated by connecting companies. Of this total wire mileage 93 per cent is copper wire.

Other industries that require copper made notable expansion, as the automobile industry.

PRICES.

The average quoted price of electrolytic copper at New York for the year 1915 was 17.47 cents a pound; in 1914 the price was 13.31 cents a pound. The average monthly prices for electrolytic copper in 1913, 1914, and 1915, as reported in "Metal statistics," published by the American Metal Market Co., are given in the following table:

Average monthly prices at New York per pound of electrolytic copper in 1913, 1914, and 1915, in cents.

Month.	1913	1914	1915	Month.	1913	1914	1915
January	16.755	14.45	13.71	August	15.68	12.415	17.22
February	15.27	14.67	14.57	September	16.55	12.085	17.70
March	14.925	14.335	14.96	October	16.54	11.40	17.86
April	15.48	14.34	17.09	November	15.47	11.74	18.83
May	15.63	14.13	18.60	December	14.47	12.93	20.35
June	14.85	13.81	19.71				
July	14.57	13.49	19.08	Average	15.52	13.315	17.47

The average price of Lake copper for the year was 17.64 cents. New York quotations are used by the United States Geological Survey in calculating the value of both mine and smelter output. It is well known, however, that this average price only approximates the the actual average price received for copper sold during the year.

The average selling price received by several large producers of electrolytic copper, as given in their annual reports, ranges from 16.079 to 19.449 cents and averages 17.33 cents a pound.

For Lake copper the average price received by the companies reporting was 17.79 cents a pound.

The average prices for each year from 1850 to 1915 are given in the prefatory note.

METALS AND ORES IN 1914 AND 1915.

By J. P. Dunlop.

INTRODUCTION.

In the detailed chapters on the various metals in Part I of Mineral Resources of the United States (to which the reader should refer for full information on the metallic resources and industries) the production is measured by the customary unit, whether the long ton of 2,240 pounds, the metric ton of 2,204.6 pounds, the short ton of 2,000 pounds, the "flask" of 75 pounds, the avoirdupois pound, or the troy ounce. The long ton is used for iron ore, bauxite, pig iron, and steel, particularly in the Eastern States, and for tin, copper, and spelter in England. The metric ton is used on the Continent of Europe, in Mexico, and wherever the metric system is in vogue. The "flask" is the customary unit for measuring quicksilver, except where the metric ton is used; the avoirdupois pound is the unit referred to in defining the tons and the "flask" and is also used for measuring the output of copper, lead, spelter, aluminum, nickel, and the other metals; the short ton is used for both ore and concentrates in the West, as well as for lead and spelter; and the troy ounce is used for gold, silver, and platinum and allied rare metals. Were the metric system in commercial use in the United States, this confusion of terms would be avoided; in its absence the production of this country by metal mines and metallurgic plants is summarized in the short ton of 2,000 pounds.

The production of metals given in the table on page 724 shows the output from plants—mills, smelters, and refineries—in the United States, and is essentially a measure of the metallurgic industry, as the ore, matte, and unrefined bullion treated in this country are derived from both domestic and foreign sources. The attempt is made, however, to show the production in marketable form of metals from both domestic and foreign mines wherever possible. The production of domestic ore is a measure of the metal-mining industry of the United States alone.

There are, roughly, four stages to be considered in the production of metal in marketable form from crude ore—(1) mining, (2) milling and concentrating, (3) smelting, and (4) refining. The first stage produces crude ore, and both straight concentrating and gold and silver milling plants produce concentrates. Both crude ore and concentrates are treated in gold and silver amalgamating, cyaniding, and chlorinating plants and in smelters, and the products are re-

fined in private refineries and the precious metals in part in the United States mints. Production may be reported, therefore, as metal in raw materials, in unrefined state, or as refined, and thus there may be three sets of figures to represent the metal output, and there may be discrepancies between these for the same metal for the same calendar year, owing to difference in the time at which the statistics were obtained, to customary losses in metallurgic operations, and to difference in activity between mining and treating the ore. In this summary the metals are taken as refined.

METALS.

Metals produced in the United States in 1914 and 1915.

1914.

Metal.	From domestic ores.		From foreign ores, matte, and unrefined bullion smelted or refined in the United States.		Total.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Iron (pig) [a]	24,035,034	$287,312,794	899,820	$11,464,635	24,934,854	$298,777,429
Manganese (spiegeleisen and ferromanganese)	75,751	1,422,039	122,888	4,604,353	198,639	6,026,392
Other ferroalloys [b]	87,003	2,604,430	545	719,423	87,548	3,323,853
Nickel	423	313,000	[c] 17,549.479	12,284,635	17,972.479	12,597,635
Aluminum [d]	39,565	14,522,700	.....	.....	39,565	14,522,700
Gold	156.788	94,531,800	30.008	18,093,023	186.796	112,624,823
Silver	2,484.176	40,067,700	1,364.199	22,003,388	3,848.375	62,071,088
Platinum and allied metals	.086	111,201	.131	169,684	.217	280,885
Quicksilver	630.350	811,680	.....	.....	630.350	811,680
Tin [e]	.....	.....	.....	.....	.....	.....
Copper, stated as refined	605,212	160,987,614	161,679	43,016,641	766,891	204,004,255
Lead, stated as refined	512,794	39,998,000	29,328	2,287,584	542,122	42,285,584
Antimonial lead	15,475	1,462,051	1,192	110,116	16,667	1,572,167
Zinc (spelter)	343,418	35,029,000	9,631	982,363	353,049	36,011,363
	.....	679,174,009	.....	115,735,845	.....	794,909,854

1915.

Iron (pig) [a]	32,972,200	$388,397,654	1,058,424	$13,011,950	34,030,624	$401,409,604
Manganese (spiegeleisen and ferromanganese)	125,819	2,376,544	164,055	9,280,449	289,874	11,656,993
Other ferroalloys [b]	143,902	3,621,264	1,505	2,172,128	145,407	5,793,392
Nickel	560	448,222	[c] 28,283.445	22,626,756	28,843.445	23,074,978
Aluminum [d]	49,903	17,985,500	.....	.....	49,903	17,985,500
Gold	167.575	101,035,700	29.339	17,689,500	196.914	118,725,200
Silver	2,570.094	37,397,300	1,748.132	25,437,500	4,318.226	62,834,800
Platinum and allied metals	.055	88,341	.242	390,347	.297	478,688
Quicksilver	788.737	1,826,912	.....	.....	788.737	1,826,912
Tin [e]	.....	.....	.....	.....	.....	.....
Copper, stated as refined	693,853	242,848,550	123,249	43,137,150	817,102	285,985,700
Lead, stated as refined	507,026	47,660,000	43,029	4,045,000	550,055	51,705,000
Antimony	2,000	1,180,000	1,544	910,960	3,544	2,090,960
Antimonial lead	19,371	3,092,675	3,853	573,061	23,224	3,665,736
Zinc (spelter)	458,135	113,617,000	31,384	7,783,232	489,519	121,400,232
	.....	961,575,662	.....	147,058,033	.....	1,108,633,695

[a] Marketed production.
[b] Includes marketed production of ferrosilicon, ferrophosphorus, ferrovanadium, ferrotungsten, ferromolybdenum. No ferrotitanium reported for 1914 or 1915.
[c] Nickel content of imported matte and ore.
[d] Includes foreign. Figures are consumption not production.
[e] No report of any tin ore smelted other than experimentally in 1914 or 1915.

Pig iron.—The marketed production of pig iron is usually reported in long tons. The output was 23,257,288 long tons in 1911, 30,180,969 tons in 1912, 30,388,935 tons in 1913, 22,263,263 tons in 1914, and 30,384,486 tons in 1915.

Manganese (spiegeleisen and ferromanganese).—The figures showing the production of the important iron-manganese alloys were formerly published by the Survey combined with those for pig iron. Statistics for the total marketed production are now available separately. The marketed production of both alloys is given as 178,615 long tons in 1911, 227,939 tons in 1912, 226,475 tons in 1913, 177,356 tons in 1914, and 258,816 tons in 1915.

Ferrosilicon and ferrophosphorus.—The combined marketed production of ferrosilicon and ferrophosphorus was 70,122 long tons in 1911, 97,371 tons in 1912, 67,164 tons in 1913, 77,182 tons in 1914, and 128,263 tons in 1915.

Other ferroalloys.—In addition to spiegeleisen, ferromanganese, ferrosilicon, and ferrophosphorus are the ferroalloys known as ferromolybdenum, ferrotitanium (with 10 to 20 per cent of titanium), ferrovanadium, and ferrotungsten (with about 50 per cent of tungsten). The combined marketed output was 4,638 long tons in 1911, 3,375 tons in 1912, 2,568 tons in 1913, 986 tons in 1914, and 1,565 tons in 1915.

Nickel.—The nickel produced in the United States from domestic ores is merely a by-product from electrolytes of the copper refineries. The foreign figures given in the table represent the content of nickel in ore and matte "imported for consumption" mostly from the Canadian (Sudbury) deposits.

Aluminum.—There are only two producers of aluminum in the United States. The figures given are those for consumption and show 47,734,000 pounds in 1910, 46,125,000 pounds in 1911, 65,607,000 pounds in 1912, 72,379,000 pounds in 1913, 79,129,000 pounds in 1914, and 99,806,000 pounds in 1915. The figures include the consumption of the imported metal as well as the domestic.

Gold and silver.—The production of gold and silver is usually given in fine ounces troy. The following table gives the output of domestic plants for 1914 and 1915:

Gold and silver produced in 1914 and 1915, in fine ounces troy.

	Domestic.	Foreign.[a]	Total.
Gold:			
1914	4,572,976	875,250	5,448,226
1915	4,887,604	855,728	5,743,332
Silver:			
1914	72,455,100	39,789,129	112,244,229
1915	74,961,075	50,987,199	125,948,274

[a] Production from foreign mines obtained from United States Bureau of the Mint.

The unrefined foreign gold and silver bullion comes mainly from Canada, Mexico, Central America, and South America, and considerable ore from which gold and silver are by-products of the smelters in base bullion is also received by domestic plants, chiefly from these countries.

Platinum and allied metals.—The production of platinum is usually reported in troy ounces. The domestic output has been de-

rived from crude platinum from gravels in Oregon and California; from copper-platinum-palladium ore from the Rambler mine in Wyoming; from gold-platinum-palladium ore from the Boss mine and adjoining properties in Clark County, Nev., and also as a by-product in refining gold and copper bullion from domestic and foreign ores.

In 1914 the production of platinum and allied metals from crude platinum and platinum-bearing ores of domestic origin was 804 fine ounces, valued at $36,012; and from the refining of blister copper of domestic origin the production was 1,696 fine ounces, valued at $75,189. In 1915 domestic crude platinum and platinum ores yielded 588 ounces, valued at $32,744, and domestic blister copper 999 ounces, valued at $55,597. Crude platinum and blister copper of foreign origin refined in the United States in 1914 yielded 3,824 ounces, valued at $169,684, and in 1915 yielded 7,078 ounces, valued at $390,347. In addition a large quantity of platinum is that recovered from dental and jewelry scrap.

Quicksilver.—The domestic output of quicksilver is produced entirely from domestic ores and is reported in flasks of 75 pounds each. The production was 21,256 flasks in 1911, 25,064 flasks in 1912, 20,213 flasks in 1913, 16,548 flasks in 1914, and 21,033 flasks in 1915.

Tin.—No tin ores were smelted in the United States in 1914 or 1915, other than experimentally, although Bolivian tin concentrates were imported pending the completion of the new tin smelter at Chrome, N. J., which was not blown in until the spring of 1916.

The estimated metallic content of the tin concentrates produced in Alaska in 1914 amounted to 104 short tons and that in 1915 to 102 tons. Nearly all the stream tin from Alaska shipped in 1914 and 1915 was exported to Singapore. The large consumption in the United States has been supplied mainly by imports, but also by recoveries of secondary tin from drosses, alloys, and scrap tin plate.

Copper.—The production of domestic copper is usually reported as blister copper in pounds. The output of blister copper from domestic ores was 1,097,232,749 pounds in 1911, 1,243,268,720 pounds in 1912, 1,224,484,098 pounds in 1913, 1,150,137,192 pounds in 1914, and 1,388,009,527 pounds in 1915. Foreign sources for copper produced and refined in the United States are Mexico, Canada, Peru, Europe, and other countries.

Lead.—The production of lead is usually given in short tons. The output of refined lead in the United States from domestic ores in 1915 was 507,026 tons compared with 512,794 tons in 1914, a decrease of about 1 per cent. The imports of foreign lead-bearing ore and base bullion for treatment in domestic plants came mainly from Mexico.

Antimony and antimonial lead.—The output of antimonial lead is mainly metallurgic by-product obtained in refining lead bullion. The output from domestic ores in 1915 was 19,371 tons compared with 15,475 tons in 1914. The only domestic antimony recovered in 1913 and 1914 was derived from a small quantity of ore mined in Nevada in 1911, but the high prices at the end of 1914 caused the opening of old antimony mines and new prospects in Alaska, California, Nevada, and other States. About 5,000 tons of domestic ores were smelted, the estimated recoverable metallic content of which was 2,100 tons.

Zinc.—The production of metallic zinc or spelter is usually stated in short tons. The output from domestic ores in 1915 was 458,135 tons compared with 343,418 tons in 1914, an increase of one-third. Imports of foreign zinc ores came mainly from Mexico, Australia, and Canada. The total quantity of spelter made from foreign ores in 1915 was 31,384 short tons, against 9,631 tons in 1914.

ORES.

The following table shows the production of crude ores supplied from domestic mines to gold and silver mills, concentrating plants, and smelters:

Crude ores produced from domestic mines in 1913, 1914, and 1915, in short tons.

	1913	1914	1915
Iron ores (marketed production)	66,800,270	44,479,994	62,152,272
Manganese ore	4,534	2,951	10,874
Manganiferous iron ore	10,808	65,390	53,976
Chromic iron ore	286	662	3,675
Tungsten ore	34,400	17,800	[a] 2,736
Titanium ore	7,600	2,350	6,250
Aluminum ore	235,470	245,636	332,686
Gold ore	9,403,622	9,669,254	11,279,354
Silver ore	1,253,116	1,297,412	1,407,772
Quicksilver ore	136,278	122,998	158,817
Tin ore	7,500	[b] 16,600	[b] 41,000
Vanadium and uranium ore	27,900	[b] 24,500	47,000
Antimony ore	116	60	5,000
Molybdenum ore	.....	.....	3,498
Copper ore:			
Western States	28,427,543	27,653,352	30,349,560
Central States	7,016,831	9,269,465	12,334,700
Eastern States	892,308	907,894	868,555
	36,336,682	37,830,711	43,552,815
Copper-lead ore	24,399	11,577	10,951
Lead ore:			
Western States	2,563,904	2,307,550	2,429,546
Central States	4,250,800	4,718,300	5,067,800
Eastern States	.....	.....	14
	6,814,704	7,025,850	7,497,360
Zinc and zinc-lead ore:			
Western States	1,658,486	2,117,558	2,412,663
Central States	10,767,340	9,747,210	14,467,100
Eastern States	692,348	901,184	1,296,305
	13,118,174	12,765,952	18,176,068
Grand total	134,215,859	113,579,697	144,742,104

[a] Not all crude ore; includes marketed concentrates from unknown quantity of crude ore milled.
[b] Estimated.

Iron ore.—Under iron ore are included 477,920 long tons of manganiferous iron ore (with low manganese content) in 1911, 816,984 tons in 1912, 612,743 tons in 1913, 347,562 tons in 1914, and 616,052 tons in 1915, shipped from Lake Superior mines. The Lake Superior and Clinton hematites are usually shipped without concentration, although there is a movement now becoming important to wash and concentrate some Lake ores, a detailed discussion of which is given in the reports on iron ore in Mineral Resources for 1914 and 1915. The eastern brown ores are usually washed to remove clay. The mag-

netites of New York are in part concentrated to remove apatite. All these ores are reported in the table as shipped or smelted.

Manganese ore.—High-grade manganese ore is produced mainly from Georgia, California, Arkansas, and Virginia, but the figures given include some output from Alabama, Arizona, Colorado, Texas, Tennessee, and Utah. The production, which amounted to 2,635 long tons in 1914, increased to 9,709 tons in 1915.

The imports of manganese ore in 1915 were 320,778 long tons, against 283,294 tons in 1914. The imports from India declined, but those from Brazil increased about 160,000 tons.

Manganese ore is used principally for the manufacture of iron-manganese alloys, as a flux in smelting, as an oxidizing and decolorizing agent, for making dry cells, and for coloring glass, brick, and pottery.

Manganiferous iron ore.—The low-grade manganiferous iron ores from the Lake Superior region are included with iron ores in the table. The remaining manganiferous iron ores come mainly from the Cuyuna region in Minnesota and from Arkansas and Virginia, and are used chiefly in making high manganese pig iron. Considerable quantities of manganiferous iron ores, mostly argentiferous, are mined in Colorado and elsewhere, and are used as fluxes in western lead smelters; they are included under ores of the precious metals.

Chromic iron ore.—Chromic iron ore or chromite is usually reported in long tons. The output, used as a pigment, in special tanning processes, for furnace linings, and in steel alloys, was 205 long tons in 1910, 120 tons in 1911, 201 tons in 1912, 255 tons in 1913, 591 tons in 1914, and 3,281 tons in 1915, nearly all from California mines. The imports in 1914 were 74,686 tons, of which 30,860 tons came from New Caledonia, 23,200 tons from Portuguese Africa, and 11,880 tons from Asiatic Turkey; in 1915 they were 76,455 long tons, of which 28,031 tons came from New Caledonia, 22,800 tons from British South Africa, 11,230 tons from Portuguese Africa, and 10,087 tons from Canada.

Tungsten ore.—Tungsten ore is usually reported in short tons. The production stated in the table is in part estimated and includes some concentrates from unknown quantity of crude ore milled. The ordinary commercial basis for tungsten ore in the United States is a content of 60 per cent tungsten trioxide. The production of tungsten concentrates on this basis in 1913 was 1,537 short tons, valued at $672,118, in 1914 it was 990 tons, valued at $435,000, and in 1915 it was 2,256 tons, valued at more than $3,500,000, of which about 960 tons were from Boulder County, Colo. California and Colorado produced most of the tungsten ore, and smaller quantities came from Nevada, Arizona, South Dakota, Washington, Connecticut, Idaho, Utah, New Mexico, and Alaska. The metal is used chiefly for making high-speed steel and the filament of the tungsten incandescent electric lamp, although the total quantity required for lamps is small.

Vanadium and uranium ores.—The production of vanadiferous ores was confined to carnotite and roscoelite. The estimated quantity of vanadium ore produced in 1914 amounted to 24,500 short tons, containing 87 tons of uranium oxide, valued at $500,000, and in 1915 the combined output or uranium and vanadium ores amounted to 47,000 short tons, containing 19.9 tons of uranium, valued at $93,750, and 627 tons of vanadium, valued arbitrarily at $600,000. The ore is estimated to

have contained 6 grams of recoverable radium, whose value in the ore is covered by that of uranium.

Titanium ore.—The domestic output of titanium ore has been mainly rutile from Virginia and amounted to 275 tons of rutile concentrates in 1912 and 305 tons in 1913. In 1914 it amounted to 94 tons of concentrates containing 95 per cent titanium dioxide, and in addition, as a by-product, 89 tons of ilmenite carrying 55 per cent of titanium dioxide. In 1915 the American Rutile Co., of Roseland, Va., produced 250 tons of rutile (titanium dioxide) and a considerable quantity of ilmenite (titanium iron oxide) as a by-product. Titanium is used chiefly for making ferrotitanium for steels and titanium carbide for electrodes, and this demand is in part supplied by the use of titaniferous magnetite and ilmenite, both of which are more plentiful and cheaper than rutile.

Aluminum ore.—The figures for aluminum ore given in the table represent domestic output of bauxite. In long tons, as usually reported, the production was 148,932 tons in 1910, 155,618 tons in 1911, 159,865 tons in 1912, 210,241 tons in 1913, 219,318 tons in 1914, and 297,041 tons in 1915. The output is derived mainly from Arkansas, which produces about 80 per cent of the ore, and from Georgia, Alabama, and Tennessee. A possible new source of aluminum is alunite, deposits of which have recently been recognized and developed in Utah and elsewhere, attention being called to them mainly as a new source of potash. A small quantity of alumina was shipped from Marysvale, Utah, in 1915. Bauxite is used chiefly as a raw material in the production of metallic aluminum and in the manufacture of aluminum salts, bauxite bricks, and alundum (an abrasive).

Gold ore.—The figures given for gold ore include siliceous, pyritic, and other ores in which the predominant value is for gold. The domestic gold output, however, is derived not only from gold ore but also from gravels of placer mines and from copper, lead, and mixed base-metal ores. Satisfactory figures for the quantity of gravels washed are not available, but it is hoped that they will be obtained by the Survey for future reports.

Silver ore.—The figures given for production of silver ore represent mainly silver-gold ores in which the value of the silver exceeds that of the gold. Of the total production in 1915, Nevada (mainly Tonopah) is credited with 836,791 short tons of such ores, New Mexico with 119,710 tons (nearly all silver-gold ore), Utah with 36,958 tons, Montana with 25,657 tons, Colorado with 188,580 tons, Texas with 54,376 tons, and Arizona with 144,198 tons. The Colorado output consists largely of iron-sulphide ores containing silver, from Leadville. Pure silver ore is rare. About two-thirds of the silver produced in the United States is derived as a by-product from lead and copper ores.

Quicksilver ore.—No quicksilver ore is imported. In 1912 the domestic output of ore treated included 139,347 short tons, averaging 0.55 per cent of the metal, in California, and 16,346 tons, averaging 1.04 per cent, in Texas and Nevada combined. In 1913 the production in California was 119,159 short tons, averaging 0.49 per cent of metal; in Nevada 8,755 tons, averaging 0.71 per cent; and in other States, including Texas, 8,364 tons, averaging 1.34 per cent. In 1914 the production in California was 101,553 short tons, averaging 0.42

per cent of metal; in Nevada 14,111 tons, averaging 0.56 per cent; and in other States, including Texas, 7,334 tons, averaging 1.62 per cent. In 1915 the production in California was 129,521 short tons, averaging 0.41 per cent of metal; in Nevada 21,975 short tons, averaging 0.40 per cent; and in Arizona, Texas, and Oregon 7,321 short tons, averaging 2.27 per cent.

Copper ore.—The copper ore of the Western States is in part concentrated and in part smelted crude. The ores from Michigan are always concentrated and those from Tennessee are smelted crude. The total quantity of copper concentrates from copper ore produced in 1910 was 2,063,824 short tons; it was 2,202,590 tons in 1911, 2,734,065 tons in 1912, 3,034,870 tons in 1913, 2,855,238 tons in 1914, and 3,215,786 tons in 1915. The average percentage of copper in crude copper ore concentrated was 1.26, and the average percentage of copper in crude copper ore smelted was 4.60. A small part of the domestic output of copper is derived from gold, lead, zinc, and mixed ores. The largest producers of concentrating copper ores were Michigan, Utah, Arizona, Montana, and Nevada, and about 47 per cent of the crude copper ore smelted was from Arizona.

Lead ore.—The lead ores of the Western and Central States are generally concentrated. The production of lead concentrates from the Central States, mainly from southeastern Missouri, was 260,967 short tons in 1910, 270,833 tons in 1911, 269,433 tons in 1912, 270,664 tons in 1913, 294,124 tons in 1914, and 328,398 tons in 1915. The output of lead concentrates in 1915 in Idaho, the largest producer among the Western States, was 255,621 short tons, the production in Utah was 149,258 tons, and that in Colorado was 109,919 tons.

The largest producer of lead ore in 1915 was Missouri, with 5,067,800 short tons, having an average recoverable lead content of 3.6 per cent. The average recoverable lead content of all lead ore was 5.8 per cent. The zinc-lead ores treated amounted to 1,915,599 tons, of which Idaho produced 513,625 tons, Montana 580,475 tons, Utah 385,361 tons, and Colorado 284,151 tons.

The following table shows the source of lead mined in the United States in 1915, by States and kinds of ore, in short tons, and the recoverable lead content of each State for each kind of ore:

Lead mined in the United States in 1915.

State.	Lead ores.			Lead-zinc ores.		
	Crude ore (short tons).	Recoverable lead content.		Crude ore (short tons).	Recoverable lead content.	
		Quantity (short tons).	Percentage.		Quantity (short tons).	Percentage.
Arizona	48,536	7,446	15.3	47,916	3,032	6.3
California	12,966	1,884	14.5			
Colorado	142,969	13,741	9.6	284,151	9,176	3.2
Idaho	1,656,688	147,276	8.9	513,525	23,826	4.6
Missouri	5,067,800	183,906	3.6			
Montana	13,783	2,139	15.5	580,475	4,607	.8
Nevada	15,508	2,611	16.8	16,940	1,549	9.1
New Hampshire and Pennsylvania	13	9	69.2			
New Mexico	8,819	1,955	22.2	71,663	171	.2
Oregon	993	26	2.5			
South Dakota	5	2	40.0			
Tennessee	1	1				
Texas	281	108	38.4			
Utah	528,009	75,902	14.3	385,361	22,954	6.0
Virginia				15,568	339	2.2
Washington	989	148	14.9			
	7,497,360	437,154	5.8	1,915,599	65,654	3.4
Percentage of total lead derived from each kind of ore			77.8			11.7

State.	Zinc ores.			All other ores.		Total.	
	Crude ore (short tons).	Recoverable lead content.		Crude ore (short tons).	Recoverable lead content (short tons).	Crude ore (short tons).	Recoverable lead content (short tons).
		Quantity (short tons).	Percentage.				
Alaska				3,390,207	437	3,390,207	437
Arizona	40,458	175	0.4	9,475,649	216	9,612,559	10,869
Arkansas	110,000	63				110,000	63
California	19,646	390	2.0	2,970,167	16	3,002,779	2,290
Colorado	100,222	140	.1	2,209,678	11,348	2,737,020	34,405
Idaho	111,428	1,891	1.7	127,205	7	2,408,846	173,000
Illinois	316,000	495	.2	(a)	459	[a] 316,000	954
Kansas	709,400	1,212	.2			709,400	1,212
Kentucky				(a)	251	(a)	251
Missouri	10,505,900	26,534	.2			15,573,700	210,440
Montana	178,573	100	.1	5,357,093	32	6,129,924	6,878
Nevada	24,816	311	1.3	5,061,356	3,848	5,118,620	8,319
New Hampshire and Pennsylvania				240,361		240,374	9
New Mexico	(b)			2,716,590	145	2,797,072	2,271
Oklahoma	891,800	7,306	.8			891,800	7,306
Oregon				154,798	5	155,791	31
South Dakota				1,889,970		1,889,975	2
Tennessee				1,149,363		1,149,364	1
Texas	60			54,687	2	55,028	110
Utah	34,320	154	.4	9,503,755	974	10,451,445	99,984
Virginia				7,191		22,759	339
Washington				85,688		86,677	148
Wisconsin	1,934,000	2,322	.1			1,934,000	2,322
	14,976,623	41,093	.3	44,393,758	17,740	68,783,340	561,641
Percentage of total lead derived from each kind of ore		7.3			3.2		100

[a] Fluorspar from which lead was recovered as a by-product is excluded.
[b] Included in lead-zinc ores.

Zinc ore.—A considerable part of the zinc ore produced is used in making pigments. Except some western ores, which are shipped crude, the zinc ores are generally concentrated. The zinc ore and concentrates of the Eastern States in 1915 were derived mainly from Franklin Furnace, N. J., the production of which nearly doubled, and there was also a largely increased output from eastern Tennessee and a small production from southwestern Virginia. The output from the Central States came chiefly from Missouri, Wisconsin, Oklahoma, Kansas, Illinois, and Arkansas, in the order named; and that from the Western States, mainly from Montana, Colorado, Idaho, New Mexico, Nevada, Utah, California, Arizona, and Texas.

The largest producer of zinc concentrates among the Western States in 1915 was Montana, with 207,280 tons. The production from the Central States in 1915 was more than 105,000 tons larger than in 1914.

The following table shows the production of zinc concentrates in recent years:

Zinc concentrates produced, 1911–1915, in short tons.

	1911	1912	1913	1914	1915
Western States	149,000	169,857	246,720	247,273	415,195
Central States	381,579	424,337	400,881	390,213	495,663
Eastern States	257,133	304,175	300,201	293,856	460,575

In 1915 the average zinc assay of sphalerite concentrates from the Joplin region was more than 57 per cent, in Montana about 45 per cent, in Arizona about 39 per cent, in Idaho about 45 per cent, and in Colorado about 42 per cent.

In 1915 there were treated 16,342,134 tons of crude zinc ore, having a recoverable zinc content of 443,610 tons, and 1,844,136 tons of lead-zinc ore having a recoverable zinc content of 139,636 tons. The quantity of zinc and zinc-lead ores treated increased nearly 50 per cent in 1915.

Zinc mined in the United States in 1915.

State.	Zinc ore.			Zinc-lead ore.		
	Crude ore (short tons).	Recoverable zinc content.		Crude ore (short tons).	Recoverable zinc content.	
		Quantity (short tons).	Percentage.		Quantity (short tons).	Percentage.
Arizona	40,458	4,888	12.1	47,916	4,198	8.7
Arkansas	110,000	3,209	2.9	.....	.....	.....
California	19,646	6,531	33.2	200	16	8.0
Colorado	100,222	19,584	19.5	284,151	29,603	10.5
Idaho	111,428	11,218	10.1	513,525	23,832	4.6
Illinois	316,000	5,534	1.7	.....	.....	.....
Kansas	709,400	14,365	2.0	.....	.....	.....
Kentucky	[a]10,000	764	7.6	.....	.....	.....
Missouri	10,505,900	136,270	1.3	.....	.....	.....
Montana	178,573	23,556	13.2	580,475	69,991	12.1
Nevada	24,816	8,037	32.8	16,940	4,130	24.4
New Hampshire and New York	14,398	[b]2,479	.....	.....	.....	.....
New Jersey	737,310	116,618	15.8	.....	.....	.....
New Mexico	[c]71,663	12,695	17.7	.....	.....	.....
Oklahoma	891,800	14,314	1.6	.....	.....	.....
Tennessee	525,829	16,461	3.1	.....	.....	.....
Texas	60	15	25.0	.....	.....	.....
Utah	34,320	4,958	14.4	385,361	7,188	1.9
Virginia	3,200	589	18.4	15,568	678	4.4
Washington	3,111	122	3.9	.....	.....	.....
Wisconsin	1,934,000	41,403	2.1	.....	.....	.....
	16,342,134	443,610	2.8	1,844,136	139,636	7.6
Percentage of total zinc derived from each kind of ore	.....	75.6	.....	.....	23.8	.....

State.	All other ore.		Total.	
	Crude ore (short tons).	Recoverable zinc content (short tons).	Crude ore (short tons).	Recoverable zinc content (short tons).
Arizona	9,524,185	24	9,612,559	9,110
Arkansas	.....	.....	110,000	3,209
California	2,982,933	.....	3,002,779	6,547
Colorado	2,352,647	3,110	2,737,020	52,297
Idaho	1,783,893	27	2,408,846	35,077
Illinois	[d]	.....	316,000	5,534
Kansas	.....	.....	709,400	14,365
Kentucky	[d]	.....	10,000	764
Missouri	5,067,800	30	15,573,700	136,300
Montana	5,370,876	26	6,129,924	93,573
Nevada	5,076,864	21	5,118,620	12,188
New Hampshire and New York	.....	.....	14,398	2,479
New Jersey	.....	.....	737,310	116,618
New Mexico	2,725,409	7	2,797,072	12,702
Oklahoma	.....	.....	891,800	14,314
Tennessee	623,535	.....	1,149,364	16,461
Texas	54,968	.....	55,028	15
Utah	10,031,764	.....	10,451,445	12,146
Virginia	3,991	.....	22,759	1,267
Washington	83,566	.....	86,677	122
Wisconsin	.....	.....	1,934,000	41,403
	45,682,431	3,245	63,868,701	586,491
Percentage of total zinc derived from each kind of ore	.....	0.6	.....	100

[a] Estimated.
[b] Part of zinc from unknown quantity of tailings.
[c] Includes lead-zinc ore.
[d] Exclusive of fluorspar ore mined in southern Illinois and Kentucky from which a small quantity of lead is recovered in milling.

MAGNESIUM.

By Frank L. Hess.

INTRODUCTION.

Elemental magnesium is known to comparatively few people and to most of those few chiefly as a silvery powder of low specific gravity, used in flash lights for photography; to a few others it is known as a narrow ribbon or as a fine granular substance, usually dark gray from oxide and other impurities, that is used in chemical work; and to a still smaller number it is known in massive form. It seems probable, however, that magnesium will become very much more common and it may become as common as aluminum.

PROPERTIES OF MAGNESIUM.

According to the descriptions in the familiar reference books, magnesium has an atomic weight of 24.32, compared with oxygen as 16, and a specific gravity of 1.74. It melts at a red heat, 633° C. (1,171° F.), and boils at a point estimated to be from 1,000° to 1,200° C. (1,832° to 2,192° F.), a temperature somewhat above the boiling point of zinc.

Magnesium, as it is now isolated, is a beautiful silvery-white metal. It commonly becomes coated with a white film of oxide in a few days or weeks; but several manufacturers have said that they have segregated magnesium having a purity of 99.99 per cent or more, which has remained untarnished or at most has shown no more tarnish than aluminum after an exposure of six to ten months in the open air. It is readily malleable and is ductile when heated. The ordinary ribbon is made by pressing the semifluid metal into wire and then flattening it. When heated in air magnesium burns with an intense white light very rich in actinic rays, and this property gives it its value in photographic work.

An important point about the magnesium data given is that most if not all of the determinations of the constants of magnesium have been made upon impure metal carrying from 0.02 to 0.5 per cent of other substances, such as iron, sodium, copper, fluorine, chlorine, and possibly various salts held mechanically or in solution. Although the quantities are small, their influence on the apparent characteristics of the metal may be considerable, just as minute quantities of phosphorus and sulphur affect steel.

Magnesium is the lightest of the metals now known that remain comparatively unaltered under atmospheric conditions. Its specific gravity (1.74) is only two-thirds that of aluminum (2.58) and two-ninths that of iron (7.86). Only the metals lithium (0.59), potas-

sium (0.86), sodium (0.97) (all members of the alkali group), and calcium (1.59) are lighter; and none of these have the chemical inertness, toughness, elasticity, and malleability that make metals valuable in the plastic arts of commerce.

DEMAND AND SUPPLY.

The demand for magnesium in previous years has been comparatively small, for the price was high, the known uses were few, and the apparently rapid alteration of the metal under atmospheric conditions did not encourage experiments in its use. The supply was naturally in keeping with the demand and was probably in general somewhat in excess. With the beginning of the European war a great demand sprang up for magnesium to be used in the unprecedentedly large quantities of war materials manufactured, but the supply, not only of the metal but of the magnesium chloride used in its manufacture, which had previously come from Germany, was cut off and caused the embarkation of American firms in the business of isolating the metal from minerals of domestic production.

HISTORY AND METHOD OF MANUFACTURE.[1]

Davy first produced magnesium in 1808 both by electrolysis and by reducing the oxide in a current of potassium vapor. Later Bunsen prepared it by the electrolysis of fused anhydrous magnesium chloride. The anhydrous chloride is difficult to prepare, and Matthiessen improved the process by substituting a mixture of 3 parts fused potassium chloride, 4 parts magnesium chloride, and a little ammonium chloride; this mixture was fused and electrolyzed. This electrolyte has the advantage of having a lower specific gravity than the magnesium, so that metal sinks.

Deville and Caron developed the first commercial method of production by reducing the magnesium in a mixture of anhydrous magnesium chloride, ammonium chloride, and fluorspar by introducing the mixture and metallic sodium into red-hot clay crucibles. They distilled the magnesium in carbon-lined vessels in an atmosphere of hydrogen and thus obtained a very pure product. Sonstedt improved the method of distillation by using close-fitting iron vessels, the upper of which held the magnesium and was heated nearly white hot, and the lower one, which projected into the upper one to a point above the magnesium and extended below the furnace, was water-cooled and collected the distilled magnesium. This process, however, was very expensive.

Magnesium is now always isolated by the electrolytic method, usually, though not everywhere, from an electrolyte of magnesium chloride with an alkaline chloride. Before the beginning of the European war the salt most generally used is said to have been the anhydrous double chloride of magnesium and potassium. This was made by fusing hydrous magnesium-potassium chloride, carnallite ($KCl.MgCl_2.6H_2O$), from Stassfurt, Germany, or by adding potassium chloride to a magnesium chloride ($MgCl.H_2O$) that carried more or less common salt (NaCl) as an impurity and was produced in great

[1] The descriptions here given are largely taken from Thorpe, Edward, A dictionary of applied chemistry, vol. 3, pp. 368-370, 1912.

quantity at Stassfurt as a by-product in the manufacture of potash salts. Magnesium chloride alone can not be made anhydrous by heating, because it partly decomposes and forms the oxide, but in the presence of an alkaline chloride such as potassium chloride, and especially if some ammonium chloride is present, the water may all be driven off without loss of chlorine.

The electrolyte is fused in an iron cell that forms the cathode. The anode is carbon and passes through a porcelain cap that collects the chlorine, and from this cap the chlorine is led away.

The magnesium is lighter than most electrolytes, so that the operation must be carried on in an atmosphere of hydrogen, nitrogen, or inert furnace gases.

To avoid the floating of the magnesium, Matthiessen's plan of adding ammonium chloride seems to be used by one firm. The particles of magnesium do not readily coalesce, and to overcome this difficulty fluorspar is added. At least one firm uses an electrolyte into which chlorides do not enter.

This in a general way outlines the process used in the isolation of magnesium as practiced in this country. The details, however, vary and the salts used are not everywhere the same.

Each company has had to work out its own technique and choose the materials to be fused. Naturally the companies have not wished to make public the information gained by their own expense and labor.

MANUFACTURE IN AMERICA.

PRODUCTION.

So far as is known to the Survey magnesium had not been produced on a commercial scale in the United States until 1915, though experiments looking toward that end had been made by various firms at different times and especially after the beginning of the European war in 1914. The General Electric Co., at Schenectady, N. Y., was the first to begin active production, probably because its own needs forced it to action, and it made a steady production throughout the year. The production of the metal was also begun about August 1 by the Norton Laboratories (Inc.), first at Nashua, N. H., and later at Lockport, N. Y.; and later in the year by the Electric Reduction Co., 50 East Forty-first Street, New York City. The Aviation Materials Corporation, Niagara Falls, N. Y., and the Magnesium Manufacturing Corporation, Rumford, Me., were ready for production at the end of 1915 but made no output. The total production during the year was 87,500 pounds, valued at about $440,000.

In Canada production was begun by the Shawinigan Electro-Metals Co. (Ltd.), subsidiary to the Shawinigan Water & Power Co., at Shawinigan Falls, Quebec.

MATERIALS USED IN AMERICAN FACTORIES.

Owing to the European war the imports of magnesium chloride from Germany were cut off and the prices of potassium salts increased so greatly that, in part at least, other salts have been used. One firm had on hand a sufficient supply of the German chloride to manufac-

ture some magnesium. Others depended on supplies developed in America. The Dow Chemical Co., Midland, Mich., supplied to several firms magnesium chloride made from the bitterns left after the extraction of salt and bromine from local brines. The Norton Laboratories (Inc.) used magnesite from the township of Grenville, Argenteuil County, Quebec, and a little from California. Magnesium chloride was made at Nashua, N. H., from the magnesite and shipped to Lockport, N. Y., for the reduction of the magnesium.

FORM AND QUALITY.

The magnesium is collected from the electrolyte, remelted, and molded into both round and square sticks from five-eighths of an inch to 2 inches thick and from 14 to 18 inches long.

The General Electric Co. sold a part of its product as a powder passing 200 mesh, for flashlights, and it sold some coarser powder for use in shells. Magnesium for flashlights must be very pure, and the company devised a process for purifying the metal.

The purity usually claimed for magnesium of domestic production is 99.5 per cent or more. Part of the product apparently is little if at all above 99 per cent magnesium. All makers agree that the magnesium made in this country is better than that formerly imported from Germany, which is declared to have had a purity of only 98 to 99 per cent.

The impurities in the metallic magnesium include calcium, sodium, potassium, fluorine, chlorine, oxygen, iron, and copper. Sodium is said to be especially undesirable, as its salts effloresce. It would seem that the presence of a little inclosed chlorine in undecomposed calcium chloride would be very undesirable on account of its being hygroscopic. Copper is thought to come from pipes used in evaporating brine.

FUTURE OF MAGNESIUM.

The writer finds it impossible to make any definite forecast as to the probable future production of magnesium. So far as can now be seen any increase in the industry will depend mostly on the discovery of new profitable or desirable uses to which magnesium may be put and on the cost of production. The cost of production in turn will depend in part upon the demand, for that will govern the size and number of the factories that can be operated. It would seem that, if uses sufficient to require a large quantity of magnesium can be developed, now is the opportune time for the establishment of the industry, for well-equipped laboratories capable of a considerable output are now in operation, but it is generally recognized that prices must fall considerably, probably to less than $1 a pound, before peaceful uses will greatly increase.

The properties of magnesium and especially of its alloys are not yet known well enough to say how useful the metal may be. It is claimed that extruded and other worked forms of magnesium attain a very considerable stiffness, but the subject needs further investigation. That magnesium alloys may be discovered which will be almost unchangeable, like stellite, the beautiful cobalt-chromium alloy made by Haynes, and that by the addition of some minor constituent, like

the carbon in steel, the metal may have its hardness, tensile strength, and elasticity greatly improved, are attractive suggestions, and such discoveries appear to be well within the bounds of possibility.

As to the probable lowering of the cost of production, manufacturers' opinions are far apart. Two or three operators believe that with further easily practicable perfection of their methods the metal can be produced for 15 or 20 cents a pound when made in large quantities. One manufacturer, however, after careful investigation and considerable experience, believes that although theoretical considerations make it seem possible to produce magnesium at 15 cents or even less a pound, technical difficulties will keep the cost up to several times that sum.

PRICES.

Before the European war magnesium was quoted at about $1.65 a pound for the imported (German) material. After the cutting off of the foreign supply prices rose to $5 or even $6 a pound for sticks, and powdered material sold at $6.50 a pound; and prices remained at about these levels through the year.

SUPPLY OF RAW MATERIAL.

Magnesium is one of the few metals of which it may be truly said that the supply of raw material, the ore, is inexhaustible. The supplies of magnesium chloride from Germany may be cut off, as they are at present, and even magnesite may become scarce, but the country has huge quantities of dolomite, the calcium-magnesium carbonate, in extensive, easily quarried beds, and the oceans themselves may be considered as reserve sources of magnesium.

Thousands of tons of magnesium carbonate are now made annually from dolomite, and should it become advisable for any reason magnesium could be made from the same rock. Dolomites carrying 40 to 45 per cent of magnesium carbonate, or 11.5 to 13 per cent of magnesium, are common and are found in many of the States.[1] The bitterns formed in making salt from sea water hold large quantities of magnesium chloride. Bitterns made at various points around San Francisco Bay, Cal., carry from 23 to 86 parts of magnesium per thousand, or 2.3 to 8.6 per cent of magnesium.[2] During 1915 some magnesium chloride has been made from these bitterns and from it a little magnesium has been made experimentally. Sea water before evaporation and abstraction of the common salt carries about 0.13 per cent of magnesium.[3] So far as man's operations are concerned the supply is illimitable and the process of concentration by solar evaporation is easy and cheap. The waters of Great Salt Lake, Utah,[4] contain about 0.56 per cent of magnesium, or more than four times as much as ocean water.

[1] Analyses of dolomites from many widely separated localities are given by E. F. Burchard in the chapter on lime in U. S. Geol. Survey Mineral Resources, 1911, pt. 2, pp. 658-707, 1912.

[2] Turrentine, J. W., The occurrence of potassium salts in the salines of the United States: U. S. Dept. Agr. Bur. Soils Bull. 94, p. 66, 1913. Samples collected by E. E. Free; analyses by R. F. Gardner.

[3] A large number of analyses of ocean water have been compiled by F. W. Clarke (The data of geochemistry, 3d ed.: U. S. Geol. Survey Bull. 616, pp. 123-125, 1916).

[4] Analysis by R. K. Bailey, quoted by F. W. Clarke (The data of geochemistry, 3d ed.: U. S. Geol. Survey Bull. 616, p. 155, 1916).

USES.

The uses of magnesium are at present neither large nor varied, and the hope for growth of the industry depends on the expansion of one or two known uses and the development of new ones.

The largest use during 1915 was in the making of war munitions. It does not enter into explosives nor into arms as an integral part, but small quantities are put in shrapnel shells in order that observers and gunners may know exactly where the shells are bursting. By day the burning magnesium gives a dense pure-white cloud of magnesium oxide that can be readily and distinctly seen, and at night it gives a dazzling white light. Larger quantities are used in aerial bombs and rockets used for lighting up the country at night. The demand for these uses is, it is to be hoped, evanescent. A small quantity of magnesium is also used in fireworks for peaceful displays, the brilliant white light and the trailing clouds of white oxide giving very beautiful effects. A number of tons are used each year for flash lights for photographic purposes. For this use the powder must pass a 200-mesh screen, otherwise it does not burn rapidly enough. It must also be free from chlorides, for, on account of their hygroscopic properties, a very small quantity seems to collect a film of water that wets the particles of magnesium and prevents their quick ignition. The powder must, of course, be unoxidized, for a film of oxide also prevents quick ignition. The powder used in shrapnel is coarser than flash-light powder. Magnesium has not found much direct use as a metal, but magnalium, an alloy of aluminum, containing 2 per cent or less of magnesium and small percentages of other metals, is said to be used in automobiles and airplanes. Magnalium is thus described by Law:[1]

> Commercial magnalium contains only a small percentage of magnesium, and, although a large number of alloys are manufactured and sold under the name of magnalium, few of these, if any, appear to contain more than 2 per cent. On the other hand, they all contain a variety of other metals, more especially copper, tin, nickel, and lead.
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> The importance of magnesium as a deoxidizer must not be overlooked, for it is even more readily oxidized than aluminum; and its beneficial influence on aluminum is in no small degree due to its power of freeing that metal from dissolved oxide.
>
> The three magnalium alloys most commonly used in this country [England] are described by the makers as X, Y, and Z. Of these, X is intended solely for castings where strength is of primary importance; Y is used for ordinary castings; and Z is intended for rolling and drawing.
>
> As regards alloy X it has been stated by Barnett that it contains 1.76 per cent copper, 1.16 per cent nickel, 1.60 per cent magnesium, and small quantities of antimony and iron.
>
> Alloy Y is somewhat similar in composition, except that it contains no nickel, but small quantities of tin and lead.
>
> Alloy Z contains 3.15 per cent of tin, 0.21 per cent of copper, 0.72 per cent of lead, and 1.58 per cent of magnesium.
>
> The tensile strength of ordinary castings with alloy Y varies from 8½ to 10 tons per square inch, and that of rolled samples of alloy Z varies from 14 to 21 tons per square inch.
>
> The alloys work well, and excellent screw threads can be cut. The speed of working is about the same as that of brass, and the tools should be lubricated with turpentine, vaseline, or petroleum. Alloy Z is exceedingly ductile, and can be spun and drawn into the finest wires. For these operations vaseline or a mixture of 1 part stearine and 4 parts turpentine has been found suitable. In drawing tubes or wire the alloy must be annealed by heating and cooling suddenly. Slow cooling produces hardening.

[1] Law, E. F., Alloys and their industrial applications, pp. 206–207, London, 1909.

* * * Magnalium is very little affected by dilute acids and can be employed with perfect safety for the manufacture of cooking utensils and all culinary appliances.

The value of magnesium as a deoxidizer is utilized by adding it to monel metal or nickel when melted for casting. It has been used in steel for the same purpose but has so far not displaced aluminum to any large extent, though it is used by some steel makers. The General Electric Co. uses magnesium as a deoxidizer in the reduction of boron.

Small quantities are used in chemistry as ribbon or coarse powder in qualitative tests for phosphorus and as rods or ribbon in the determination of potash.

Among the uses of magnesium to which manufacturers look forward are its employment to replace aluminum as a deoxidizer in steel, and also to replace aluminum, in part, in automobiles and airplanes.

IMPORTS AND EXPORTS.

Neither imports nor exports of magnesium are on record in the customs returns, but the imports during 1915 were small. In the statistics issued by the Bureau of Foreign and Domestic Commerce the figures for magnesium are entered with those of "barium, calcium, sodium, and potassium, and alloys of which said metals are the component materials of chief value," all of which are subject to a 25 per cent duty. The imports of all five metals in 1915 amounted to 11,310 pounds, valued at $14,000. All but 211 pounds, valued at $583, was imported in the first quarter of the year.

NICKEL.

By Frank L. Hess.

INTRODUCTION.

No nickel ores are known to have been mined in the United States in recent years, but an equivalent of 822 short tons of nickel was saved in 1915 as a by-product in the electrolytic refining of copper. Of this output the larger part was marketed as metallic nickel and the smaller part was contained in hydrous nickel sulphate.

What part of this nickel came from American pig or blister copper and what part from foreign copper is uncertain, but it is roughly estimated that American ores produced between one-half and two-thirds of the whole. The foreign copper came from many countries and from every continent. The companies reporting a production were the American Smelting & Refining Co., Nichols Copper Co., Raritan Copper Works, and United States Metals Refining Co.

The great bulk of the nickel supply of the United States has been drawn for years from Canada. During 1915 smaller quantities were imported from New Caledonia, Australia, and Norway.

During the general stock taking which has been going on in the United States during the last year many questions as to the country's resources in nickel have been asked, and in order to answer these questions and to show what nickel and nickel ore would be available in case of urgent need and shortage of supplies from other countries, the information available on the deposits of the United States has been epitomized in this paper.

The nickel deposits of the United States are small compared with the unrivaled deposits at Sudbury, Canada, but they have in the past made some production and will probably do so again. Nickel in quantities sufficiently large to excite attempts to exploit the deposits on a commercial scale has been found in California, Colorado, Connecticut, Idaho, Missouri, Nevada, New Mexico, North Carolina, Oregon, Pennsylvania, Virginia, and Washington under very diverse conditions and smaller deposits have been found in other States.

NICKEL MINERALS.

Short descriptions of the chief nickel minerals are given below in order that the reader who may not have the composition of these somewhat rare and unusual substances in mind may more easily read what follows. Nearly all nickel minerals may have cobalt, nickel's lesser twin, replacing a part of the nickel.

Annabergite.—Annabergite is a hydrous nickel arsenate ($Ni_3As_2O_8$, $8H_2O$). It is apple-green and generally soft and earthy. It is a weathering product of those minerals that contain nickel and arsenic and is also known as nickel bloom. Some annabergite contains cobalt.

Dudgeonite is annabergite with about one-third of the nickel replaced by calcium.

Cabrerite is annabergite with a part of the nickel replaced by magnesium.

Arite.—See Niccolite.

Awaruite.—See Josephinite.

Breithauptite.—Breithauptite is a nickel antimonide (NiSb). It is an unusual mineral; opaque, with a bright metallic luster, light copper red color inclining strongly to violet, and a reddish brown streak. It is a vein mineral. See Niccolite.

Chloanthite.—Chloanthite is nickel diarsenide ($NiAs_2$), but is rarely found pure. It generally contains more or less cobalt and iron and merges by imperceptible degrees into smaltite, the cobalt diarsenide. It has a hardness of 5.5, a metallic luster, is opaque, is tin-white to steel-gray in color, and has a grayish black streak. Chloanthite containing considerable iron has been called chathamite.

Garnierite.—See Genthite.

Genthite.—Genthite is a hydrous magnesium nickel silicate (about $2NiO.2MgO.3SiO_2.6H_2O$), but the composition of various specimens may be greatly different. The nickel content may range from more than 45 per cent NiO downward to the vanishing point, when the mineral is known as gymnite. It is a delicate or dark apple-green, its color depending upon the percentage of nickel present. It is amorphous, translucent, and may have a hardness as high as 4, though some may be cut by the finger nail. It was named in 1867. In 1875 similar material found in New Caledonia was named garnierite and noumeite. Garnierite is described as pale green and adhering to the tongue, and noumeite as dark green and unctuous. Genthite is a secondary mineral formed by the breaking down of olivine or serpentine carrying nickel and is the mineral from which the New Caledonian nickel is obtained. It is found in this country at Riddle, Oreg., Webster, N. C., and in less quantity at other places.

Gersdorffite.—Gersdorffite is a sulparsenide of nickel (NiAsS), but it may contain iron or cobalt or both and less nickel. It is opaque, has a metallic luster, is silver-white to steel-gray in color, has a hardness of 55, and a grayish black streak. It crystallizes in cubes, like pyrite, and has an uneven fracture. It is probably an original vein mineral.

Josephinite.—Josephinite is a native alloy of iron and nickel of the composition Fe_2N_5. It is found in small quantity in stream gravels of southwestern Oregon and northern California.

Awaruite is another native alloy of nickel and iron. It is found in the gravels of Gorge River near Awarua Bay, South Island, New Zealand. It has the formula $FeNi_2$.

Both minerals are probably weathered from basic dikes. Neither has been found in quantity sufficient to be of commercial value.

Millerite.—Millerite is a nickel sulphide (NiS). It is usually in slender capillary crystals, but these may grow together, forming crusts having a columnar structure and a brown, velvety surface. It

is opaque, brass-yellow to bronze-yellow, and has a hardness of 3 to 3.5 and a greenish-black streak.

It is probably generally, if not always, a secondary mineral, and it was prominent in the deposits at Gap, Pa.

Niccolite.—Niccolite is a nickel arsenide (NiAs). It is rarely found theoretically pure, but may contain iron, cobalt, sulphur, and antimony. The antimonial varieties grade into breithauptite, the nickel antimonide (NiSb). The intermediate varieties have been called arite.

It has a metallic luster, is usually pale copper-red, has a hardness of 5 to 5.5 and a pale brownish-black streak.

It is found in veins, such as those of Cobalt, Ontario, Silver Cliff, Colo., and the Bullards Peak district, N. Mex.

Pentlandite.—Pentlandite is an iron-nickel sulphide approximating 2FeS.NiS in composition. It is opaque, has a metallic luster, light bronze-yellow color, light bronze-brown streak, and a hardness of 3.5 to 4. It has a distinct octahedral cleavage.

Pentlandite is the principal nickel mineral in the Sudbury ores and apparently in nearly all those deposits in which the nickel minerals are original parts of an igenous mass, as at Gap, Pa.; in Floyd County, Va.; near Bunkerville, Nev.; and elsewhere.

Polydymite.—Polydymite is a nickel sulphide (perhaps Ni_4S_5). It is opaque, has a brilliant metallic luster (but tarnishes easily), light to steel gray color, and a hardness of 4.5. It has a cubic cleavage. It sometimes contains iron and then approximates $Ni_3Fe_2S_5$. It is found at Sudbury, Ontario, and apparently is the nickel mineral at Julian, San Diego County, Cal.

Pyrrhotite.—Pyrrhotite, or magnetic pyrites, is a sulphide of iron with a composition in which the molecule seems to contain one more atom of sulphur than of iron—Fe_nS_{n+1}, approaching FeS. It is not a nickel mineral, though there are many references in the literature to "nickeliferous pyrrhotite." Since metallographic microscopes and methods of examination have been perfected, it has been shown that pyrrhotite carrying nickel always incloses a nickel mineral, usually if not always pentlandite. It is well to examine rocks containing pyrrhotite for nickel. It is opaque, has a metallic luster, color between bronze-yellow and copper-red, streak dark grayish black, and a hardness of 3.5 to 4.5. It may be distinguished from ordinary pyrite (FeS_2) by the fact that it is attracted by a magnet.

FORMS OF OCCURRENCE OF NICKEL.

The occurrences of nickel according to their form and origin seem to fall into nine classes, not all of which, however, are now of economic value. The classes are:

1. Basic igneous rocks carrying sulphides of nickel with pyrrhotite as original constituents. This group may be subdivided into—
   (*a*) Deposits in which the sulphides have segregated at or near the edges of the mass.
   (*b*) Deposits in which the sulphides are distributed more or less evenly through the mass.
2. Nickel sulphides in regionally metamorphosed rocks.
3. Basic igneous rocks carrying nickel as an original silicate.
4. Hydrous nickel magnesium silicates formed through the decomposition of rocks carrying nickel silicate.

5. Lateritic iron ores carrying nickel, cobalt and chromium.
6. Veins carrying nickel sulphides, antimonides, and arsenides.
7. Sulphide deposits carrying traces of nickel, but in which copper or lead is the principal metal of economic value.
8. Placers carrying native alloys of nickel and iron.
9. Meteorites.

In class 1 are the great deposits at Sudbury, Ontario, and the smaller deposits at Gap, Pa., and both belong to subclass (*a*). The Norwegian and German deposits also belong to this class. Smaller nickel-bearing intrusions in which segregation has not taken place are found near Bunkerville, Nev.; East Union, Maine; and in Floyd County, Va.

In class 2 are apparently the deposits in quartzite at Blackbird, Idaho, and near Litchfield, Conn. In both places the deposits are more or less connected with amphibolitic rocks and a migration of the minerals from the amphibolite seems a possibility.

In class 3 are the dunites of North Carolina and the olivine-bearing rocks at Riddle, Oreg., and other places. They are of no commercial value at the present time, but through their decomposition are formed the hydrous nickel-magnesium silicates of class 4.

In class 4 are the deposits at Riddle, Oreg., and a part of the deposit at Webster, N. C. The large deposits of New Caledonia, next to those of Sudbury in size, also are of this type.

Class 5 has no known representatives in the United States. Lateritic iron ores are deposits of small nodules of brown iron ore formed through the decomposition of serpentine, which has, of course, been formed through the alteration of peridotites or other basic rocks. The lateritic iron ores of Mayari, eastern Cuba, carry from 0.38 to 1.8 per cent of combined nickel and cobalt, mostly nickel. During 1915, 337,004 short tons of these ores were imported into the United States. If they carried 1 per cent of nickel and cobalt, 3,370 short tons of these metals were contained, nearly all of which was reduced with the iron and passed into the steel made from it.

Class 6 includes the veins at Silver Cliff, Colo., and Bullards Peak, N. Mex. The famous cobalt-bearing veins at Cobalt, Ontario, also belong to this class. They carry calcite and other carbonates and native silver.

Class 7 includes such deposits as the copper veins of Butte and the great disseminated copper deposits of the country. Such deposits would in general be valueless as nickel mines, but nickel is obtained as a by-product in the electrolytic refining of copper from them. The disseminated lead deposits of southeastern Missouri also belong to this class in form but possibly their origin is much different from that of the others mentioned. They are in part apparently rich enough to be worked at a profit for nickel.

Class 8 includes the josephinite found in placers of Josephine County, Oreg., and Trinity County, Cal., and the awaruite of New Zealand stream gravels. The deposits have been of no commercial value.

Class 9, meteorites, has so far been of no commercial importance. Metallic meteorites contain an alloy of iron and nickel, of which the nickel usually is between 5 and 10 per cent, but may reach 60 per cent.

It is thought that the topographic feature known as Meteor Crater or Coon Butte, near Canyon Diablo, Ariz., was formed by the fall

of a huge meteorite. Thousands of dollars have been spent in exploratory work for the meteorite which it was thought might be buried and would be of value for its nickel and iron, but no such mass has been found, and to account for its absence Merrill [1] suggested that the meteorite may have been largely vaporized by the heat generated when it struck the rocks.

NICKEL RESOURCES OF THE UNITED STATES.

California.—A nickel deposit on the Friday claim, 4 miles south of Julian, San Diego County, has been described by F. C. Calkins,[2] and a specimen of genthite has been sent to the Geological Survey from Coyote Mountain, Imperial County, near the San Diego County line.

Considerable work has been done on the Friday deposit at Julian, at first in the belief that the deposit would be of value as a copper producer. The nickel mineral is an iron-bearing polydymite ($Ni_3Fe_2S_5$) and is accompanied by chalcopyrite, pyrrhotite in large quantity, pyrite, and possibly by marcasite, as the sulphides oxidize rapidly in the air. The ore is also accompanied by amphibole and calcite and is in a chimney in gabbro near a contact with schist. The gabbro is cut by a thin dike of pegmatite, and at a depth of 250 feet the ore has been cut off by a fault.

Assays showing from 2.94 per cent of nickel upward are reported, two apparently reliable assays showing 4.12 and 4.34 per cent. Copper, according to reported assays, ranges from a trace to 2.4 per cent. No mention of cobalt is made, but it would be exceedingly exceptional if some should not be present.

A considerable quantity of nickel-bearing rock has been piled on the dump, but the breaking down of the sulphides has formed sulphuric acid which has attacked both nickel and copper, forming sulphates that have been readily leached away by rains.

The Friday deposit is about 25 miles northeast of Foster, the nearest railway station, and 60 miles from San Diego, with which it is connected by a good road. Little is known of the deposit on Coyote Mountain. The country is exceedingly dry and lacks timber, but a railroad planned to extend from San Diego to Yuma will probably bring transportation facilities equal to those of Julian.

Colorado.—The Gem mine, near Silver Cliff, Custer County (then a part of Fremont County), at one time produced some nickel and cobalt ore.[3] The ores were taken from a vein cutting hornblende schist. At the surface copper was the important metal, but at a depth of 15 or 20 feet nickel sulphide and sulpharsenide (polydmite and gersdorfite (?)) became prominent. From the surface to a depth

[1] Merrill, G. P., The meteor crater of Canyon Diablo, Ariz.; its history, origin, and associated meteoric irons: Smithsonian Misc. Coll. Quart. Issue, vol. 4, pt. 4, pp. 494–495, 1908. The occurrence and work in the crater have been described by D. M. Barringer. See his article, Meteor Crater (formerly called Coon Mountain or Coon Butte) in southern central Arizona, read before Nat. Acad. Sci. Nov. 16, 1909. (Privately published, 24 pp. 18 pl., 2 plans.)

[2] The description of the deposit at Julian is taken from Calkins, F. C., An occurrence of nickel ore in San Diego County, Cal.: U. S. Geol. Survey Bull. 640, pp. 77–82, 1916 (Bull. 640-D).

[3] Charlton, Thomas, Discussion of Philip Argall's paper "Nickel: The occurrence, geological distribution, and genesis of its ore deposits": Colorado Sci. Soc. Proc., vol. 4, pp. 420–421; read Dec. 4, 1893.

of 75 feet, at which point it pinched out, the vein averaged between 3½ and 4 feet in width.

By drifting and sinking, a vein 18 inches wide was found, which may have been an extension of the vein first worked. The vein carried some rich native silver, but as a rule the ores showed little silver and only a trace of gold. The wall rock was so hard that mining the ore was difficult and expensive. In 1882 12 tons of ore, carrying 12 per cent nickel, between 2 and 2.5 per cent cobalt, and considerable copper, mostly in the form of chalcocite, was shipped from the mine. At a later date half a ton of selected ore, which contained 34 per cent nickel and between 3 and 4 per cent cobalt, was shipped to Swansea, England. The nickel in this lot was in the form of niccolite. The mine was soon afterwards closed on account of litigation, and its subsequent history is unknown.

George [1] mentions that annabergite is found with niccolite in the Gem and other mines near Silver Cliff.

Connecticut.—Connecticut is not ordinarily considered a mining State and few know that at one time it supported nickel and cobalt mining. Blake [2] gives the following history of nickel mining in the State:

> The locality at Chatham, Conn., about 6 miles from Middletown, yields both nickel and cobalt in combination with arsenic and sulphur. The ore occurs in mica slate. It is not now worked, but it was one of the first places explored for metals in New England. As early as the year 1661 the inhabitants of Middletown made a grant to "our much-honored governor, Mr. John Winthrop, for the discovery of mines and minerals and for the setting up of such works as shall be useful for the improvement of them." It is probable that the governor hoped to find silver, being misled by the white, shining ore. Neither nickel nor cobalt had then been discovered. About 100 years later, in 1762, Dr. John Sebastian Stephanney, a German, reopened the old works, and in 1770 associated John Knool and Gominus Eskelens with him, and worked the mine for cobalt. In 1781, January 1, President Stiles, of Yale College, wrote in his diary that Mr. Eskelens had visited him "full of his cobalt mine and China voyage. He some years ago bought the governor's ring, as it is called, or a mountain in the northwest corner of East Haddam, comprehending about 800 acres, or about a square mile area. Here he finds plenty of cobalt, which he manufactures into smalt, with which is made the beautiful blue of chinaware." Some 20 tons of cobalt ore appear to have been shipped to China from this locality. Nothing more appears to have been done for 30 years. In 1818 Mr. Seth Hunt, of New Hampshire, worked the mine for three years, and expended about $20,000. The ore was taken to Glastonbury and stamped by hand. He obtained, as he supposed, about 1,000 pounds of cobalt and shipped it to England, where it was found to be nickel, containing only a low percentage of cobalt. The difficulty in separating the nickel from the cobalt caused him to abandon the property. The mine was again reopened by Prof. Charles U. Shepard in 1844, but with no greater success.
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> In 1853 an attempt was made to work the mine on a larger scale than before, and a company known as the Chatham Cobalt Mining Co. was organized for the purpose. The assays made at the time upon the dressed ores show that they contained about 18 per cent of nickel and cobalt in nearly equal quantity, or 9 per cent of each. The firm of William Coffin & Co., then operating in nickel at Camden, near Philadelphia, offered to take all the ore that could be produced up to 200 tons annually of that grade and pay $200 per ton (of 2,240 pounds) for it on the wharf at Philadelphia. Cobalt at that time was worth 14 shillings sterling per pound, and nickel $1.70 per pound. According to a report by Mr. Simonin it appears that the average metallic contents of the ore as mined, before dressing, was 2.2 per cent. The property was examined

[1] George, R. D., Common minerals and rocks, their occurrence and uses: Colorado Geol. Survey Bull. 6, p. 168, 1913.
[2] Blake, W. P., Nickel: U. S. Geol. Survey Mineral Resources, 1882, pp. 401–402, 1883.

and reported upon in 1855 by Prof. J. C. Booth, of the United States Mint, who found that the ore crushed and washed in a Bradford's ore separator yielded a product averaging about 20 per cent of the oxides of nickel and cobalt in nearly equal parts. This company made a good display of the ores and products at the International Exhibition, New York, 1853. The second annual report of the company, by Dr. Francfort, the manager, though very complete as regards the amount of machinery and facilities for working brought together during the 18 months after the organization, is silent as regards the production, which it may be assumed was comparatively insignificant. The enterprise was soon after abandoned. It is believed that a small quantity of nickel from this source reached the mint.

Other localities in Connecticut.—There are small quantities of nickel at other places in the ancient schists of Connecticut. The principal localities, however, are at Torrington, where nickel ore was once mined on a considerable scale, most of it being sent to England, but the undertaking was an unprofitable one and was not long continued. The Litchfield nickel mine is about 10 miles farther south and yielded ores similar to those obtained at Lancaster Gap, in Pennsylvania. Neither of these localities have been worked for many years. The mines are full of water, and an old furnace formerly used for smelting the ore is in ruins.

Gregory[1] states that the rock in which the nickel is found near Litchfield is a norite. Chalcopyrite and pyrrhotite are found in the less feldspathic parts.

Chathamite, a variety of chloanthite containing nearly as much iron as nickel and cobalt, was described from Chatham, where it is associated with arsenopyrite and niccolite in slate.

The deposits are apparently without economic value at the present time.

Idaho.—Nickel deposits have been known near Blackbird, Lemhi County, for many years and have been repeatedly referred to in these reports. They have been briefly described by J. B. Umpleby.[2]

The Blackbird district is about 35 miles by stage road from Salmon, the nearest railroad station. The nickel minerals are annabergite, the hydrous nickel arsenate ($Ni_3As_2O_8.8H_2O$); niccolite, the nickel arsenide (NiAs) questionably found; and pyrrhotite shown by assay to carry 0.8 per cent nickel. The nickel in pyrrhotites from widely separated localities has been shown by Campbell and Knight[3] to be contained in pentlandite inclosed in the pyrrhotite, and it is not likely that the ores of Blackbird are an exception. On the Togo claim pyrrhotite is apparently an original constituent of a gabbro dike. On the Beliel claims the nickel-bearing rock is chiefly mineralized quartzite with some schist. At one place a sample taken across a face 20 feet wide gave 2 per cent nickel and less than 1 per cent cobalt.

No commercial production has been made from the claims.

Maine.—A small deposit of peridotite carrying pyrrhotite and nickel and intrusive in metamorphosed sediments probably of late Cambrian or early Ordovician age lies about three-fourths of a mile southwest of the village of East Union, Knox County.[4] Samples of the rock contained 0.94 per cent nickel sulphide (NiS), 0.03 per cent cobalt sulphide (CoS), and 1.03 per cent chalcopyrite (CuFeS). The deposit is only 40 or 50 feet across and does not promise to be of com-

[1] Rice, W. N., and Gregory, H. E., Manual of the geology of Connecticut, p. 111, 1906.
[2] Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 71–72, 159–165, 1913.
[3] Campbell, William, and Knight, C. W., On the microstructure of nickeliferous pyrrhotites: Econ. Geology, vol. 2, pp. 350–366, 1907.
[4] Bastin, E. S., A pyrrhotite peridotite from Knox County, Maine—a sulphide ore of igneous origin: Jour. Geology, vol. 16, pp. 124–138, 1908.

mercial importance as a source of nickel. Half a mile southeast of the dike is a rusty outcrop, which is supposed to be the weathered portion of a similar dike.

Near Rumford a creamy-white sericite-quartz schist carries numerous small crystals of pyrite, and these are said to carry somewhat more than 1 per cent of nickel, but the pyrite forms only a small percentage of the schist so that the deposit holds little promise of commercial profit. An attempt to exploit the deposit a few years ago met no success.

Missouri.—The nickel deposits of Missouri are on the eastern side of the St. Francis Mountains, in the vicinity of Fredericktown, and on the Mine La Motte property, in Madison County. Here, according to Winslow, galena is disseminated through a Lower Silurian dolomite [1] now known as the Bonneterre (Upper Cambrian) limestone. The dolomite grades into sandstone, which in some places contains glauconite. It is underlain by an impure sandstone, also of Cambrian age, and this sandstone in turn rests on Archean granite and porphyry.

Here and there galena is disseminated through the dolomite and in places also considerable pyrite, chalcopyrite, and some nickel and cobalt sulphides, the latter probably combined in the mineral linnæite.[2] The sulphides, other than galena, are found in greatest quantity in the lower part of the workings, next to and in the sandstone, especially near the granite and porphyry.

The quantity present varies considerably in the different workings. The mines have generally been operated for lead, and nickel and cobalt have been produced as by-products, except from the mines worked by the North American Lead Co. Genth [3] states that the ores from Mine La Motte had been used as a source of nickel and cobalt oxides for a number of years prior to 1857. In the milling of the lead ores the sulphides of iron, copper, nickel, and cobalt which were saved were thrown aside, though a considerable percentage seems to have been lost in the tailings.

At one time the Mine La Motte ores were smelted to matte at the mine and the matte was sold to the refinery at Camden, N. J., and to others abroad. Concerning the ores treated, J. M. Neill states: [4]

> Our staple lead ore, the dressed galena, is the chief source of nickel and cobalt. It carries but a small percentage of these metals, viz, 0.2 to 0.3 per cent usually, though when much copper pyrites is contained in the gangue the amount of nickel and cobalt may be as great as 1 to 1.5 per cent. Next in importance is the "middle product" of the dressing works, consisting of the sulphides of iron (and copper) with gangue and galena. This usually carries 20 to 23 per cent of lead, 0.5 to 1 per cent of copper, and 2.5 to 3.5 per cent of nickel and cobalt. A larger percentage of copper always carries with it an increase of nickel and cobalt. In some cases 12 to 15 per cent of copper gives

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[1] Winslow, Arthur, and Robertson, J. D., Lead and zinc deposits: Missouri Geol. Survey, vol. 7, p. 649, 1894.

[2] An analysis was made of the mineral by F. A. Genth and published in the Am. Jour. Sci., 2d ser., vol. 23, pp. 419–420, 1857, under the caption "Siegenite (nickel-linnæite) from Mine La Motte, Missouri." Genth obtained the following result:

Sulphur	41.54	Insoluble	1.07
Lead	.39	Copper	Trace.
Nickel	30.53	Antimony	Trace.
Cobalt	21.34		
Iron	3.37		98.24

The analysis is not very satisfactory, but clean material is difficult to obtain.

[3] Op. cit., pp. 419–420.

[4] Neill, J. M., Notes on the treatment of nickel-cobalt mattes at Mine La Motte: Am. Inst. Min. Eng. Trans., vol. 13, pp. 634–639, 1885.

6.5 to 8 per cent of these metals. Besides these products of the dressing works, there is a small quantity of true nickel-cobalt ore produced, which, averaging only 1 to 2.5 per cent, has until lately been of small importance. Through recent developments in the deeper workings, where the nickel, cobalt, and copper sulphides occur disseminated (but separate from one another) in a porous sandstone, the amount of this ore has been largely increased.

The North American Lead Co. erected a smelter in 1906 for treating the sulphides which had accumulated on its own and adjoining properties and also the ores as mined. In 1907, 2,731 pounds of cobalt oxide were made. In 1909, 83,394 pounds of cobalt oxide, 328,403 pounds of nickel, 8,214 tons of nickel and cobalt concentrates, 600 tons of copper, and 1,353 tons of lead concentrates were produced. In 1908, a body of ore 400 or 500 feet from the granite was 12 feet thick, and was said to carry 10 per cent copper, 4 per cent nickel and cobalt, and 4 per cent lead. This ore had been reached by a long drift in which the ore had been 1 to 2 feet thick, gradually increasing in thickness to the point noted. The company's affairs later became so involved that the property was sold at a forced sale in 1910 and has since remained idle. Plans for again starting work have repeatedly been reported.

Besides the properties named, those of the Hudson Valley Lead Co., Madison Lead & Land Co., 4 miles from Fredericktown, and the Jackson Revelle Co., 8 miles south of Fredericktown, are said to carry similar nickel deposits. From the meager data at hand it seems probable that some hundreds of tons of nickel per year can be produced, with possibly one-fourth to one-third as much cobalt and several times as much copper.

Nevada.—Considerable work has been done on nickel deposits at two localities in Nevada. Several deposits are located in Cottonwood Canyon, on the east slope of the Stillwater Range, in Humboldt County, about 45 miles southeast of Lovelock, near latitude 40° N.[1]

The Nickel mine [owned by the American Nickel Co.] is situated on the north side of Cottonwood Creek, from 3 to 4 miles above Boyer's ranch. It was opened about 1882, when, it is reported, a car of 26 per cent nickel ore was shipped to Camden, N. J., and was worked for eight years. It was then closed in consequence of litigation. Work was resumed in 1904 but ceased again in 1907.

The workings are on a contact between diorite and andesite or andesite breccia, the rock being too much altered for certain identification. The contact, which is here more regular than elsewhere and may be due to local faulting, strikes N. 50° E. and dips 35° NW., the diorite forming the foot wall. The ore, which is all in the andesitic rock, has been exploited by cuts, tunnels, and an inclined shaft about 200 feet deep. It occurs in narrow fissures that make various angles with the contact and are not individually persistent. Some ore has been followed for a distance of 100 feet from the contact, measured perpendicularly to that plane. The diorite in the foot wall shows fissuring and disturbance and carries stringers of quartz, but no ore.

The seams of nickel ore are rarely over 3 or 4 inches in width, and all the material seen was more or less oxidized. The original filling, of which some residual masses remain, is partly a sulpharsenide of nickel, probably gersdorffite, according to Mr. W. T. Schaller, who tested the material in the Geological Survey laboratory. It is probable that chloanthite and other nickel minerals are also present, as the original ore has the appearance of being in part a mixture of arsenides or sulpharsenides of nickel. The residual kernels

[1] Ransome, F. L., Notes on some mining districts in Humboldt County, Nev.: U. S. Geol. Survey Bull. 414, pp. 57–58, 1909.

of sulpharsenide are veined and coated with a bright-green hydrous nickel arsenate, probably annabergite, as determined by Mr. Schaller. This constitutes most of the ore. No quartz or other distinctive gangue mineral was noted in the veinlets. The nickel minerals are not confined to the major fissures, but have penetrated the rock in their vicinity for several inches along joints and microscopic cracks, forming a low-grade ore which the company has attempted to treat by leaching with sulphuric acid.

The Lovelock mine, about half a mile west of the Nickel mine, is reported to have shipped a total of about 500 tons of high-grade nickel-cobalt ore, but has long been idle. The workings comprise a labyrinth of superficial burrowings, by which the miners have followed or sought for the small erratic veinlets of ore, and a precarious shaft that no attempt was made to explore. This shaft is said to have been sunk to water and to be connected with exploratory drifts just above the water level. It apparently is not much more than 100 feet deep. The country rock is altered andesite like that at the Nickel mine. No diorite was seen, but it would probably be cut in deep workings.

The seams or veinlets of ore run in practically all directions and have no definite walls. The ore, all of which is partly or wholly oxidized, is more complex than that of the Nickel mine and contains copper and cobalt as well as nickel. The minerals recognized are tetrahedrite, erythrite (cobalt bloom), azurite, and green crusts that, according to Mr. Schaller, contain copper and nickel arsenates and sulphates and consequently may be a mixture of annabergite and brochantite.

There are also a number of other nickel-bearing claims in the canyon.

In southeastern Nevada considerable work has been done on nickel deposits in the Copper King mining district, Clark County. Bancroft[1] describes their location as in the Virgin Range a little west of south and 16 miles from Bunkerville, and 24 miles S. 75½° E. of Moapa, though by road the distance is 35 or 40 miles. Since Bancroft's report was written the San Pedro, Los Angeles & Salt Lake Railroad has built a branch to St. Thomas, on Virgin River, making transportation much easier.

Halfway up the slopes of Virgin Mountain a strip of gneiss, probably of pre-Cambrian age, has been exposed by the erosion of the overlying sandstones and limestones. The gneisses stand nearly vertically and have been intruded by various basic rocks, aplite, and pegmatite. The two last are later than the metamorphism of the region. The darker intrusives have been more or less crushed, and their strike parallels that of the gneiss. They are comparatively small, 100 feet or more long and 10 to 50 feet wide, and are commonly faulted both horizontally and vertically. In some of them nickel, cobalt, and platinum have been found; and on two claims, the Key West and the Great Eastern, considerable work has been done. The Great Eastern dike is an almost black enstatite-mica picrite, a rock containing augite, olivine, biotite, and enstatite—their relative abundance being in the order named. The rock also contains magnetite, pyrite, pyrrhotite, chalcopyrite, and some chromite, apparently original constituents of the rock. About 600 feet of shafts and drifts had been driven when the property was examined by Bancroft.

An assay of one of Bancroft's samples gave 0.26 per cent of nickel and a trace of platinum. The copper was not determined. Assays of two Great Eastern specimens reported by the company gave: Copper, 1.5 and 2.01 per cent; nickel, 0.9 and 5.39; cobalt (one), 0.04; platinum, 0.25 and 0.17 ounce; and in one traces of gold and silver.

[1] Bancroft, Howland, Platinum in southeastern Nevada: U. S. Geol. Survey Bull. 430, pp. 192–199, 1910.

The Key West claim is a mile southwest of the Great Eastern, 500 feet lower, and nearer Virgin River. The Key West is on a dike which is supposed to be of about the same composition as that on which the Great Eastern is located. The pyrrhotite seems to have been altered to pyrite. Assays of specimens of the decomposed dike taken near the surface showed 1.47 per cent nickel and 0.1 ounce platinum and 5.6 per cent nickel and 0.12 ounce platinum. A specimen thought to be from another dike, found only between levels 2 and 3, gave 4.66 per cent nickel, 0.55 ounce platinum, a trace of gold, and no silver.

In 1908 a carload of ore was shipped to the North American Lead Co., Fredericktown, Mo., which, according to analysis, contained 1.79 per cent nickel, 0.08 per cent cobalt, 2.30 per cent copper, 10.59 per cent iron, and 6.90 per cent sulphur; and 0.13 ounce of platinum, a trace of gold, and 0.35 ounce of silver per ton of 2,000 pounds. No arsenic was present.

On the Key West there was a little over 3,000 feet of development work at the time of Bancroft's visit, and the main shaft was down 312 feet.

The nickel seems to be in the pyrrhotite, probably, as is usual, as inclosed pentlandite.

New Mexico.—In 1888 Hillebrand [1] described an arsenide of nickel and cobalt, chloanthite, from the Rose mine, Grant County, N. Mex., but no further printed reference to the deposit is known.

The deposits are covered by the Alhambra, Alhambra Extension, Black Hawk, and other claims in the Bullards Peak mining district, 12 miles west of Tyrone.[2]

The country rock is granite and is cut by large porphyritic dikes. The veins were made up of calcite, dolomite, barite, and some quartz, and were worked for silver, of which large masses were found. In a letter dated October 21, 1916, W. George Waring states that in 1893 and 1894:

> At the time of my visit there was one solid mass of native silver 60 or 70 feet long, 6 inches to 18 inches thick, extending 1 or 2 feet above the floor of the drift for the entire length of the mass. The arsenical nickel mineral or minerals did not accompany this mass—they were found farther southwest, near to the Rose mine, in which they were fairly abundant.

In one place in the Alhambra vein a shoot, possibly the one just referred to in the quotation from Waring, from 2 to 3 feet wide (other dimensions are not given) is said to have carried from 15 to 20 per cent of nickel, in the form of niccolite, and the ore was rich in silver.

North Carolina.—At Webster, Jackson County, in the western part of North Carolina, nickel in the form of the hydrous nickel magnesium silicate, genthite, is found in thin veinlets cutting dunite, a rock composed of olivine with particles of magnetite and chromite. The dunite, which here forms hills and ridges several miles long, itself carries as much as 0.5 per cent nickel,[3] although the general

[1] Hillebrand, W. F., Mineralogical notes: Colorado Sci. Soc. Proc., vol. 3, pp. 46–47, 1888.

[2] Information from Albert A. Leach in letter dated May 31, 1916, and from a private report of W. George Waring on the Alhambra mine, 1894, also kindly furnished by Mr. Leach.

[3] Genth, F. A., Contributions to mineralogy: Am. Jour. Sci., 2d ser., vol. 33, pp. 199–200, 1862.

content is considerably lower. An analysis of the genthite, which is derived from the decomposition of the olivine forming the dunite, gave F. P. Dunnington[1]: SiO_2, 49.89; MgO, 22.35; NiO, 16.60; FeO, 0.06; H_2O, 12.36; total 101.26. Although the analysis is not all that might be desired, it gives a sufficiently accurate idea of the material for general use.

These deposits have been known for many years but are of too low grade to be very attractive commercially. About 10 years ago, however, exploitation was undertaken upon a report that large quantities of rock carrying 1 per cent of nickel could be quarried. More than $600,000 is said to have been expended on testing and the erection of a plant. Expensive electrical and other machinery was installed and an attempt was made to smelt the material in an electric furnace into a merchantable nickel-silicon-iron alloy to be used in making steel. After a few experimental runs the plant was closed down.

Oregon.—Nickel deposits were discovered on Nickel Mountain, 3½ miles west of Riddle, Douglas County, Oreg., in 1864, but were not recognized as such until 1881.[2]

Ever since the identification of the nickel more or less development work has been done on claims located on the deposits and numerous shafts and prospect tunnels have been driven.

Kay estimated that in 1906 between 3,000 and 4,000 tons of material had been taken from the various openings and thrown on dumps where it still remained, but had had its nickel content considerably leached through weathering. Since that time further work has been done on the claims. Only a few small shipments of ore have been made to smelters, and these were merely for experimental purposes. In 1893 the International Mining Co. shipped considerable mining machinery to Riddle, but it was never used. About the same time the company erected near the deposits an engine and boiler house, a blacksmith shop, and other buildings, all of which are now in a more or less dilapidated condition.

The nickel deposits are associated with a Mesozoic intrusion of saxonite or harzburgite, a variety of peridotite, an igneous rock consisting mostly of olivine and enstatite. Olivine forms more than two-thirds of the whole rock. As in all such rocks chromite and magnetite are sprinkled through the mass, and in some places there are notable segregations of the chromite. Large masses of the peridotite have been altered to dark-green serpentine, and, as in other similar areas, there is a great deal of brecciation, faulting, and sheeting. Along some sheeted zones, especially those that are flat lying, there are veins of genthite, the hydrous nickel magnesium silicate. The olivine carries, according to analyses quoted by Kay, 0.26 to 0.32 per cent nickel oxide (NiO). A specimen of the serpentine carried 0.45 per cent nickel oxide.

There can be little doubt that the deposits have had their origin, as Kay and others have stated, in the decomposition of the olivine, whether directly and simultaneously with the formation of the serpentine or whether through the breaking down of the serpentine which had formed first is uncertain. It seems probable that both processes may have taken place. In either case Kay's hypothesis that

[1] Quoted by Mallet, J. W., Notes of work by student sof practical chemistry in the laboratory of the University of Virginia: Chem. News, vol. 25, p. 270, 1872.

[2] Kay, G. F., Nickel deposits of Nickel Mountain, Oreg.: U. S. Geol. Survey Boll. 315, pp. 119–127, 1907. The description given is nearly all from Kay's article.

the ores will extend no deeper than the breaking down of the peridotite seems correct, because both the formation and the decay of the serpentine are probably in part coincident, though of course until the bulk of the rock was serpentinized, formation took place more rapidly than decay.

Analyses of ore such as may be mined in some quantity seem to show a content of from 5 to 8 per cent nickel. Data are not at hand to show how much ore may be available.

Pennsylvania.—About 3 miles southwest of Gap, Lancaster County, Pa., is a deposit of nickeliferous peridotite which was at one time probably the most important known deposit of nickel in the world.

The deposit was discovered about 1718[1] and for 80 or 90 years after its discovery the deposit was worked by various companies for copper, but all failed. In 1849, after the mine had lain idle for 30 or 40 years, mining for copper was again attempted, and a mineral occurring in some abundance and termed by the miners "mundic," the Cornish word for pyrite, was produced and thrown away. In 1852 Charles Doble, a miner, recognized that this material was not pyrite, and after some trouble in having it identified the owners sent it to Dr. F. A. Genth, who recognized it as millerite.

A smelter was erected, but the company was unable to make a profit owing to the lack of knowledge of the metallurgy of nickel, and in 1860 the mine was again closed. In 1862 the property was purchased by Joseph Wharton, who rebuilt and enlarged the matte smelter. He also established a refinery at Camden, N. J. Wharton at once commenced trying to improve the metallurgy of nickel, and he is said to have been the first to make malleable nickel as a commercial product, and of his exhibit at Paris in 1878 it was said that theretofore "very few chemists had ever seen nickel." Before that time nickel had been reduced only as an alloy of copper, probably with more or less cobalt, and in this form it had been used in various alloys, especially German silver. On the exhibit he received the golden award, his competitors showing only nickel plate or nickel alloys.[2] The total production of nickel from the Gap mine up to the end of 1882 was estimated at 4,000,000 pounds.[3] After the hard work of developing the mine, and the processes for treating the ore had met with considerable success, the competition of the silicate ores of New Caledonia became so strong that in the early eighties nickel from the island was ruling the markets and by 1893 nickel from the pyrrhotite ores of Sudbury, Ontario, had also entered into competition so strongly as to cause the closing of the Gap mine; it has since remained closed. During the time that the Gap mine was operated, it furnished the United States Mint with nickel for coining.

The Gap nickel deposit is a segregation of pyrrhotite[4] carrying pentlandite from an amphibolite dike about 300 feet wide, which as

[1] Doble, Charles, quoted by Frazer, Persifor, jr., The geology of Lancaster County: Pennsylvania Second Geol. Survey Rept. CCC, pp. 163–171, 1880.
The history of the mining operations at the Gap nickel mines is taken from Doble's account; the geology and mineralogy largely from Frazer, op. cit., pp. 171–176, and from Kemp, J. F., The ore deposits of the United States and Canada, 3d ed., pp. 431–434, 1900.

[2] Blake, W. P., Nickel: U. S. Geol. Survey Mineral Resources, 1882, p. 418, 1883.

[3] Idem, p. 409.

[4] Campbell, William, and Knight, C. W., On the microstructure of nickeliferous pyrrhotites: Econ. Geology, vol. 2, pp. 364–365, 1907.

exposed is somewhat boat shaped, and intrudes rocks in " a prolongation of the same Eozoic belt which makes the Gap Hills and Welsh Mountain and has been heretofore considered under the name of the Georgetown series. The area thus referred to is almost surrounded by limestone, the broad Lancaster limestone bounding it on the north and the Chester Valley limestone on the south."[1]

The pyrrhotite occurs on the outside of the dike,[2] mostly on the southeast side, around the eastern pointed end, and it occurs also as a smaller strip on the northeast side, as shown in a geologic sketch map published by Kemp.[3] Little pyrrhotite is found in the center of the amphibolite, but orbicules of hornblende have formed all through the pyrrhotite, as shown by a splendid specimen of the ore weighing half a ton which is in the United States National Museum. Some chalcopyrite is also found in the ore.

Frazer [2] spoke of the ore as principally millerite, but the millerite occurred in cracks as crusts formed of compact masses of needle-shaped crystals half an inch or less in length and having a fine velvety-brown surface, though brass yellow in the interior, and was evidently a product of downward enrichment. Millerite was of secondary importance as an ore mineral, though much more conspicuous than the more important pentlandite, which can be seen only with a microscope.

The upper 50 or 60 feet of the deposit was nearly barren,[4] and from this leached zone the millerite was evidently formed. The ore as mined carried from 1 to 3 per cent nickel, about one-twentieth as much cobalt, and one-third as much copper.[5]

No data are at hand by which to measure the effect of the millerite enrichment nor the depth to which it was found, but evidently, should need arise, this old deposit could again be made to produce a considerable quantity of nickel.

The total production seems to have been equivalent to about 3,000 tons of nickel.

South Dakota.—F. R. Carpenter,[6] then dean of the Rapid City School of Mines, has been quoted as authority for the statement that copper deposits in the crystalline rocks in the Black Hills were derived " from pyrite or pyrrhotite containing nickel," and deposits on Spring Creek are especially mentioned. Prof. Carpenter reported an average of 15 per cent nickel in the pyrrhotite examined, and other assays showed 8 per cent. Zeigler [7] mentions, seeemingly with some doubt, the occurrence of niccolite on Spring Creek, on the Rapid City-Hill City road, and on French Creek, near Custer.

The deposits do not appear to be of commercial value under present conditions.

Virginia.[8]—A dike of gabbro 18 to 22 feet wide, in northeastern Floyd County, about 7 miles directly south-southeast of Shaws-

[1] Frazer, Persifor, jr., The geology of Lancaster County: Pennsylvania Second Geol. Survey Rept. CCC, p. 163, 1880.
[2] Idem, p. 173.
[3] Kemp, J. F., Ore deposits of the United States and Canada, 3d ed., p. 433, 1900.
[4] Doble, Charles, quoted by Frazer, Persifor, jr., op. cit., p. 171.
[5] Idem, p. 169.
[6] U. S. Geol. Survey Mineral Resources, 1888, pp. 109–110, 1890.
[7] Zeigler, Victor, The minerals of the Black Hills; South Dakota School of Mines Bull. 10, p. 64, 1914.
[8] The description of nickel deposits in Virginia is mostly taken from Watson, T. L., The occurrence of nickel in Virginia: Am. Inst. Min. Eng. Trans., vol. 38, pp. 683–697, 1908.

ville, carries about 15 per cent by bulk of pyrrhotite disseminated through the mass and is reported to contain 1.75 per cent or more of nickel, a fraction of 1 per cent of copper, and as much as 0.4 per cent of cobalt. The nickel-bearing mineral has not been determined. Openings have been made in a nearly northeast to southwest direction for a distance of 4.5 miles. The nickeliferous gabbro and the inclosing rocks are all fresh and very tough, so that mining is difficult and expensive.

Assays of pyrite from the same general locality are said to show 3 to 4 per cent nickel, but it is not known which nickel mineral is present. Considerable prospecting has been done on the deposits, and a company now has in hand plans for their exploitation.

Washington.[1]—For years considerable prospecting for nickel has been done on the Congress claim, in the Sanpoil district, Ferry County. The claim is on Bridge Creek, 3½ miles east of Sanpoil River, between 30 and 35 miles a little east of south from Republic and the same distance a little east of north from Wilbur.

* * * The deposit occupies a shear zone or fault plane in a schistose series of amphibolite, lime shale, quartz-mica schist, and a rock which resembles sheared granite. These rocks are intruded by quartz monzonite porphyry, which has caused some contact metamorphism in the contiguous strata. The vein filling is chiefly jointed and fractured quartz of a bluish-white color, accompanied by some talc and barite. Sparsely scattered through the quartz are small veinlets and aggregates of pyrite associated with some chalcopyrite. The pyrite is slightly nickeliferous, and where oxidation has been active the sulphides have been altered and their oxidation products, limonite, malachite, and a carbonate of nickel have been deposited as a thin film along the joint planes and fractures in the quartz. The oxidized portions of the vein contain 0.12 to 0.246 per cent of nickel and 0.013 to 0.034 per cent of cobalt. A picked specimen of sulphide ore showed 5.71 per cent of nickel and 0.35 per cent of cobalt.

In the oxidized ores the nickel content is low, but as the picked specimen of sulphide ore showed over 5 per cent of nickel it seems possible that this deposit might be profitably worked below water level, where oxidized material would be practically absent and where sulphides should predominate. Because of the scanty distribution of the nickel-bearing sulphide ores in the quartz vein, the ore would have to be concentrated.

This ore deposit was probably formed by solutions accompanying the intrusion of the quartz monzonite porphyry, which caused more or less contact metamorphism in the adjacent rocks. The evidence for this conclusion lies in the presence of magnetite, epidote, and barite in the contiguous strata.

The occurrence of amphibolite in close connection with the deposit, as is commonly the condition in many other deposits, makes it seem possible that there may be a closer connection between it and the nickel than between the quartz monzonite and the nickel, but not a great deal is known of the nickel minerals present.

MARKET FOR NICKEL ORES.

During 1915 there was no known market for nickel ores in the United States. The large smelting companies bought only gold, silver, lead, zinc, and copper ores, and if nickel were present no allowance was made for it. As the nickel can be smelted with the copper into matte and can be separated in electrolytic refining and as nickel is now being saved by the refineries, it would seem that the purchase of nickel ores might be made mutually profitable to both smelters and miners.

[1] Bancroft, Howland, The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, pp. 30, 182–185, 1914.

PRODUCTION.

No direct production of nickel from American nickel ores is known to have been made in this country since 1909, when the American Lead Co. operated a smelter at Fredericktown, Mo., for a short period.

In the electrolytic refining of copper the nickel, which is found in small quantity in practically all blister or other copper that has not been previously electrolytically refined, goes into solution in the electrolyte. The electrolyte must be watched in order that not more than 1 per cent of nickel shall accumulate, for excess of this quantity is said to interfere with the smooth deposition of the copper and thus to cause short circuiting and other troubles.

From the electrolytes the nickel is saved as nickel sulphate. Formerly a large quantity of nickel ammonium sulphate was also made, but none is now reported. The other companies sell the nickel sulphate, which is used for nickel plating, but the American Smelting & Refining Co. reduces the salts saved in its refineries to metal.

The first production of by-product nickel in the electrolytic refining of copper known to have been made in this country was made in 1908. During the last five years the saving has been as follows:

Nickel content of salts and metallic nickel produced as by-product in electrolytic refining of copper, 1911–1915.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1911	445	$127,000	1914	423	$313,000
1912	328	93,600	1915	822	538,222
1913	241	79,393			

IMPORTS.

As usual the great bulk of the nickel imported was in matte from the International Nickel Co.'s. smelter at Copper Cliff, Ontario, the ores coming from their mines at Sudbury. Mines and smelter in Canada are operated by a subsidiary company known as the Canadian Copper Co. The matte, which carries about 62 per cent of nickel, is shipped for refining to another subsidiary, the Orford Copper Co., at Bayonne, N. J. Matte from New Caledonia is refined by the United States Nickel Co., at New Brunswick, N. J.

Nickel ores and nickel matte are specifically exempted from duty,[1] but imported "nickel, nickel oxide, alloy of any kind in which nickel is a component material of chief value, in pigs, ingots, bars, rods, or plates" must pay a duty of 10 per centum ad valorem; sheets or strips 20 per centum.[2]

The imports of nickel for consumption in the United States for several years, as reported by the Bureau of Foreign and Domestic Commerce, have been as follows:

[1] Tariff Act of Oct. 3, 1913, sec. 565.
[2] Idem, sec. 155.

Nickel imported for consumption in the United States, 1910–1914.

Year.	Nickel, nickel ore and matte, nickel oxide, alloys of nickel with copper, etc.[a]		Value of manufactured articles of nickel.	Total value.
	Quantity.	Value.		
	Pounds.			
1910	32,363,251	$4,213,079	$14,759	$4,227,838
1911	29,829,268	4,022,716	27,314	4,050,030
1912	46,317,078	5,724,431	34,536	5,758,967
1913	47,446,520	6,562,555	38,200	6,600,755
1914	35,098,958	5,000,594	28,224	5,028,818
1915	56,599,381	7,629,686	6,458	7,636,144

[a] Includes only the nickel content of ore and matte. No ore is known to have been imported into the United States in 1911, 1912, or 1913.

Forms of nickel imported for consumption in the United States in 1914 and 1915.

Form.	1914		1915	
	Quantity.	Value.	Quantity.	Value.
	Pounds.		*Pounds.*	
Nickel, alloys, pig, bars, etc	106,019	$42,678	31,990	$13,557
Ore and matte (nickel content)	34,989,745	4,956,448	56,566,594	7,615,999
Nickel oxide	3,194	1,468	497	130
	35,098,958	5,000,594	56,599,381	7,629,686

Origin of nickel ore and matte imported into the United States in 1915.

	Quantity.	Nickel content.	Value.
	Shorttons.	*Pounds.*	
France	443	691,807	$162,663
Canada	43,123	53,638,101	6,997,422
Peru	1	118	13
Australia	1,093	979,941	217,740
French Oceania (New Caledonia)	1,138	1,042,615	238,161
	45,798	56,352,582	7,615,999

The imports from Peru and Australia were ores. The high-grade matte from France was probably made from New Caledonian ores.

EXPORTS.

The United States refines much more nickel than it can use, so that though not a large producer it is a large exporter.

Nickel, nickel oxide, and matte[a] exported from the United States, 1910–1915.

Year.	Quantity.	Value.
	Pounds.	
1910	15,244,937	$4,704,088
1911	25,099,586	8,283,777
1912	25,815,016	8,515,332
1913	29,173,088	9,686,794
1914	27,595,152	9,455,528
1915	26,418,550	10,128,514

[a] No nickel matte is known to have been exported in the years 1911 to 1915, inclusive.

CANADIAN PRODUCTION.

As the United States receives much the larger part of its nickel from Canada, those who are concerned with nickel are interested in Canadian conditions of production.

From time to time movements have been started to compel the refining in Canada of the nickel matte produced in that country. Export taxes and other means have been proposed; and in 1915, owing largely to the interest due to the European war, another such movement was launched, and a commission consisting of Messrs. George T. Halloway, a well-known metallurgist of London, chairman; Willet G. Miller, Provincial geologist, of Ontario; McGregor Young, K. C., of Toronto; and Thomas W. Gibson, deputy minister of mines, of Ontario, was appointed by the provincial government of Ontario to study the situation. The personnel of this commission will give great weight to its report. Its investigations continued through the year. Concerning the production in 1915 McLeish [1] says:

Refined metallic nickel is now being recovered in Canadian refineries, but only in small quantities and as a by-product in the smelting and refining of the silver-cobalt ores of the Cobalt district, nickel oxide having been recovered in these smelters for several years. The nickel-copper ores of the Sudbury district, supplemented by a small tonnage of similar ores from the Alexo mine, in Timiskaming, north of Cobalt, are the main sources of nickel production, which in 1915 increased nearly 50 per cent as compared with 1914 and is greater than the production in 1913, the largest previous record, by over 37 per cent.

The nickel-copper ore, derived from 12 separate mines, is reduced in smelters and converters to a Bessemer matte containing from 77 to 82 per cent of the combined metals, and shipped in that form to Great Britain and the United States for refining, the product of the Canadian Copper Co. going to New Jersey and that of the Mond Nickel Co. to Wales. A portion of the matte produced by the Canadian Copper Co. is used without the intermediate refining of either metal for the direct production of Monel metal, an alloy of nickel and copper.

The total production of matte in 1915 was 67,703 tons, containing 39,216,165 pounds of copper and 68,077,823 pounds of nickel, and valued by the producers at $10,352,344. The tonnage of ore smelted (part being previously roasted) was 1,272,283. The production in 1914 was 46,396 tons of matte, containing 28,895,825 pounds of copper and 45,517,937 pounds of nickel and valued at $7,189,031.

The reported recovery of nickel from the ores of the Cobalt district was 55,325 pounds of metal and 200,032 pounds of nickel oxide. The recovery in 1914 was 392,512 pounds of nickel oxide.

The exports of nickel are reported by the customs department as 66,410,400 pounds, valued at $7,394,446, or an average of 11.13 cents per pound.

Nickel produced in Canada, 1911–1915, in short tons.

Form of product.	1911	1912	1913	1914	1915
Ore mined	612,511	737,584	784,697	1,000,364	1,364,048
Ore smelted	610,834	725,065	823,403	947,053	1,272,283
Bessemer matte produced	32,607	41,925	47,150	46,396	67,703
Copper content of matte	8,966	11,116	12,938	14,448	19,608
Nickel content of matte	17,049	22,421	24,838	22,759	34,039
Spot value of matte	$4,945,592	$6,303,102	$7,076,945	$7,189,031	$10,352,344

Nickel contained in matte, etc., exported from Canada, 1911–1915, in pounds.

Destination.	1911	1912	1913	1914	1915
Great Britain	5,023,393	5,072,867	5,164,512	10,291,979	13,748,000
United States	27,596,578	39,148,993	44,224,119	36,015,642	52,662,400
Other countries			70,386	220,706	
	32,619,971	44,221,860	49,459,017	46,538,327	66,410,400

[1] McLeish, John, Preliminary report on the mineral production of Canada during the calendar year 1915, pp. 11–13, Canada Dept. Mines, 1916.

TEST FOR NICKEL.

The following directions for a test for nickel have been prepared by W. C. Wheeler:

Grind to a fine powder a sample—2 or 3 grams (30 to 40 grains); treat in a test tube with a few cubic centimeters of aqua regia (a mixture of 1 part nitric acid and 3 or 4 parts of hydrochloric acid), and boil nearly to dryness; then add enough nitric acid and water to dissolve all soluble substances. Filter if necessary. Dilute to 10–15 cubic centimeters (about one-third the capacity of a test tube 6 inches long and three-fourths of an inch in diameter), add a gram or more (half a teaspoonful) of citric acid (solid), and dissolve by heating. Make the solution slightly ammoniacal, noting that it should contain no precipitate. To the slightly ammoniacal solution add about 2 cubic centimeters (a half teaspoonful) of 1 per cent alcoholic solution of dimethylglyoxime. A voluminous scarlet precipitate indicates nickel.

The aqua regia solution is boiled nearly to dryness to remove from it the large excess of acid and anything, such as hydrogen sulphide, that would cause the precipitation of iron, cobalt, nickel, etc., in the ammoniacal solution.

The citric acid will prevent the precipitation of iron and aluminum as hydroxides, but will not prevent the precipitation of sulphides of iron, cobalt, nickel, and some other metals in the ammoniacal solution.

If a brown precipitate of iron forms after the solution is made ammoniacal, it contains an insufficient quantity of citric acid.

USES.

The uses of nickel depend on its properties of toughening, whitening, hardening, increasing the elasticity, and preventing the oxidation of certain alloys; on its own resistance to alteration under atmospheric conditions; its beautiful white luster; the high polish it takes; and the ease with which it is electroplated. As with all other metals, its use depends on the fact that it is isolated from its ores with comparative ease and cheapness.

The greatest use for nickel is as an alloy in steel. Of nickel steels Stoughton [1] says:

> Nickel steels are the most important of all the alloy steels and are the most abundantly used. In the ordinary commercial alloys the nickel ranges from 1.50 to 4.50 per cent, and usually from 2.00 to 3.75 per cent, while the carbon is usually from 0.20 to 0.50 per cent. Not counting armor plate, which is really a quarternary steel containing both nickel and chromium, the most important uses of nickel steel are for structural work in bridges, railroad rails, especially on curves, steel castings, ordnance, engine forgings, shafting, especially marine shafting, frame and engine parts for automobiles, wire cables, axles, especially for automobiles and railroad cars, etc. We can best learn the reasons for these particular uses by discussing the distinctive properties conferred by the nickel and their usefulness.
>
> *Tensile properties.*—The chief distinction between nickel steel and carbon steel is the higher elastic limit of the former, and especially the fact that this higher elastic limit is obtained with only a slight decrease in ductility. About 3.50 per cent of nickel added to carbon steel will increase the elastic limit nearly 50 per cent, while reducing the ductility only about 15 to 20 per cent. It is this increase in elastic limit which is probably the chief reason for the increased

[1] Stoughton, Bradley, The metallurgy of iron and steel, 2d ed., pp. 390–392, 1911.

resistance of nickel steel to what is known as "fatigue," that is to say, its resistance to repeated stresses and alternating stresses,[1] under which all steel will ultimately break down, even though the load is far less than that it can bear indefinitely if constantly applied. It is probable that the minute structure of nickel steel is also advantageous in this same connection. About 3.50 per cent of nickel will give steel approximately six times the life in resistance to fatigue. The records of shipping show that the great majority of accidents to vessels at sea come from the breaking of the propeller shafts, which is doubtless due to alternate stresses, because these long shafts are put out of alignment by each passing wave; so now practically all large vessels use hollow nickel-steel shafts. It is the higher elastic limit that is responsible also for the use of nickel steel in bridges, ordnance, automobile parts, and wire cables, for we may obtain equal strength with less weight or greater strength with the same weight. Besides the elastic limit, the ultimate tensile strength of [carbon] steel is increased also by the addition of nickel. The increase is not so great in this particular, and consequently the elastic ratio—that is the ratio of the elastic limit to the tensile strength—is increased still more greatly. The elastic limit of ordinary rolled carbon steel should be at least one-half of the tensile strength, while that of 3.50 per cent nickel steel should be at least 60 per cent.

The crystalline structure of nickel steel is more minute and the modulus of elasticity is about the same as that of carbon steel, and it is harder.

The alloy of iron and nickel known as "invar" is called a steel. Invar containing 36 per cent of nickel is practically without expansion or contraction when exposed to varying temperatures. It is used for scientific instruments, pendulums, and steel tapes.

An alloy of 25 per cent nickel and 75 per cent copper is used in the 5-cent piece or "nickel" of United States coinage. The small coins of Belgium, Denmark, England, France, Sweden, and Switzerland contain some tin and zinc, the Italian coins only tin, and Chilean coins contain copper 70 per cent, nickel 20 per cent, and zinc 10 per cent.[2] Some other countries use pure nickel for their subsidiary coins. From 1857 to 1864 the United States used a composition of 12 per cent nickel and 88 per cent copper in 1-cent pieces, a very much better alloy than that now in use which is 95 per cent copper and 5 per cent tin and zinc.[3]

Monel metal is an alloy of nickel and copper made by the International Nickel Co. by smelting the Sudbury ores without separating the two metals. As stated by the Bayonne Casting Co. the composition is 67 per cent nickel, 28 per cent copper, and 5 per cent other metals, probably mostly iron and a little cobalt. It has a tensile strength equal to good nickel steel, resists many corrosive agents, and has a color and takes a polish equal to that of nickel. It is used for propellers for warships and smaller craft, including racing motor boats; for valves on high pressure steam lines; valve stems; pump rods and liners; acid pumps; burning points in enameling and japanning ovens; pickle frames and rods in tin-plate mills; wire cloth; golf-club heads; and roofing materials.

The addition of a small percentage of nickel makes a silver-white alloy with copper, and considerable quantities of nickel are used in the alloy known as German silver, used as a substitute for the more

[1] Repeated stresses are stresses put upon a body at intervals and relieved meanwhile, while alternate stresses are stresses first in compression and then in tension, such, for instance, as the stresses in a wire that is bent backward and forward, or in a rotating shaft that is not absolutely in alignment.

[2] Brannt, W. T., The metallic alloys, pp. 307–308, 1908.

[3] Director Mint Ann. Rept., 1911, p. 9, 1912.

valuable metal. German silver is used direct for table ware and other utensils and as a base for silver-plated ware.

Nichrome is a proprietary name for an alloy of nickel and chromium which was first used for resistance wires in electrical work. It stands temperatures considerably above a red heat with little oxidation and without melting, so that it is used in small resistance furnaces in place of platinum. It is also used for chemists' triangles, etc., for making carbonizing pots, and in wire cloth for dipping baskets where articles are to be dipped in acid solutions.

The following alloys of nickel are noted by Brannt,[1] Liddell,[2] and others:

Analyses of nickel alloys.

Alloy.	Copper.	Zinc.	Nickel.	Lead.	Iron.	Tin.	Silver.	Cobalt.
Alkali-resisting metal, for soap factories, etc.	.....	.....	5.00	.....	95.00	.....	.....	.....
Bearing metals, according to Winckler	50.00	.....	25.00	.....	.....	25.00	.....	.....
Beer-glass lids	59.23	23.31	16.27	0.28	0.28	0.12	0.02Sb	0.42
Calorite (U. S. patent No. 901425; October, 1908, Dempster to General Electric Co.)	.....	5.00Mn	62.00	.....	20.00	.....	13.00Cr	.....
Constantan	60.00	.....	40.00	.....	.....	.....	.....	.....
German silvers:								
Alfénide, according to Bolley	59.00	30.00	10.00	.....	.....	.....	.....	.....
Alfénide for table ware, according to Rochet	59.10	30.20	9.70	.....	1.00	.....	.....	.....
American German silver, copper 96, zinc 36, nickel 24, cobalt 1, iron 1, tin 2, silver 2, manganese 2	58.00	21.70	14.50	2.40Mn	0.60	1.20	1.20	0.60
Argentan, Berlin	52.00	22.00	26.00	.....	.....	.....	.....	.....
Articles to be soldered, white, hard, brittle	53.00	23.00	22.00	.....	2.00	.....	.....	.....
Articles to be soldered, according to Gersdorff	57.00	20.00	20.00	3.00Pb	.....	.....	.....	.....
Birmingham German silver for tableware	62.40	22.15	15.05	.....	.....	.....	.....	.....
Castings, copper 2, zinc 1, nickel 1, lead 0.12	48.50	24.30	24.30	2.90	.....	.....	.....	.....
Castings, copper 5, zinc 2, nickel 2, lead 0.18	54.59	21.80	21.80	1.90	.....	.....	.....	.....
Castings, copper 60, zinc 20, nickel 20, lead 3	58.30	19.40	19.40	2.90	.....	.....	.....	.....
China silver, according to Meurer	65.24	19.52	13.00	.....	Trace	2.00As	.....	.....
Chinese German silver, very ductile and softer than German	26.30	36.80	36.80	.....	.....	.....	.....	.....
Closely resembling silver	57.70	27.10	14.30	0.80	.....	.....	.....	.....
English German silver (Liddell)	61.30	19.10	19.10	.....	.....	.....	.....	.....
English German silver, somewhat more yellow than German	60.00	17.80	18.80	.....	.....	.....	.....	3.40
French German silver, according to D'Arcet	50.00	30.00	20.00	.....	.....	.....	.....	.....
French German silver, according to Chaval	58.30	25.00	16.70	.....	.....	.....	.....	.....

[1] Brannt, W. T., The metallic alloys, 3d ed., pp. 320–323, 1908.
[2] Liddell, D. M., The metallurgist's and chemist's handbook, 1st ed., pp. 480–483, 1916.

Analyses of nickel alloys—Continued.

Alloy.	Copper.	Zinc.	Nickel.	Lead.	Iron.	Tin.	Silver.	Cobalt.
German silvers—Contd.								
German German silver, according to Bolley	54.00	28.00	18.00	.....	.....	.....	.....	.....
German German silver, according to Frick	55.50	29.10	17.50	.....	.....	.....	.....	.....
Hardware metal; harness trimmings, etc.; casts well; doesn't roll.	50.00	34.90	15.00	.....	.....	.....	0.10Al	.....
Maillechort, French, according to Levoir	55.00	15.00	30.00	.....	.....	.....	.....	.....
	60.00	15.00	25.00					
	65.00	20.00	15.00					
	60.00	20.00	20.00					
Maillechort, Paris, according to Henry	65.40	13.40	16.80	.....	3.40	.....	.....	.....
Markus's alloy for thermopiles. Parts: 10 Cu, 6 Zn, 6 Ni	45.50	27.30	27.30	.....	.....	.....	.....	.....
Packfong, Chinese	43.80	40.60	15.60	.....	.....	.....	.....	.....
Packfong, Chinese, best quality, according to Fyfe	40.40	25.10	31.60	.....	2.60	.....	.....	.....
Packfong, English, according to Engström	40.60	43.70	15.60	.....	.....	.....	.....	.....
Paris white metal for spoons, forks, etc	69.80	5.50	19.80	.....	.....	.....	.....	.....
Paris yellow metal	79.70	0.28	13.65	.....	.....	0.09	.....	.....
Sheffield German silver, very elastic	57.40	25.00	13.00	.....	3.00	.....	.....	.....
Sheffield German silver	57.00	19.00	24.00	.....	.....	.....	.....	.....
Sheffield German silver, copper 60, nickel 20, zinc 20, iron 2, lead 3, very white and brittle	57.10	19.00	19.00	1.90	3.00	.....	.....	.....
Solder for German silver; melts easily; flows well	45.00	45.00	10.00	.....	.....	.....	.....	.....
Spoon metal, according to Schubarth	50.00	31.25	18.75	.....	.....	.....	.....	.....
Tutenag, Chinese, for casting, very fusible, of a beautiful white color, but hard, and difficult to roll	45.70	36.90	17.40	.....	.....	.....	.....	.....
Vienna German silver:								
Copper 2, zinc 1, nickel 1, for forks and spoons, not very white, but hard and does not tarnish	50.00	25.00	25.00	.....	.....	.....	.....	.....
Copper 5, zinc 2, nickel 2, for forks and knives; resembles silver 0.750 fine	55.60	22.20	22.20	.....	.....	.....	.....	.....
Copper 3, zinc 1, nickel 1, resembles silver 0.750 fine; readily rolled and worked	60.00	20.00	20.00	.....	.....	.....	.....	.....
Hydraulic bronze; for pressures up to 3,000 pounds per square inch	83.00	5.00	2.00	5.00	.....	5.00	.....	.....

Analyses of nickel alloys—Continued.

Alloy.	Copper.	Zinc.	Nickel.	Lead.	Iron.	Tin.	Silver.	Cobalt.
Invar:								
Platinite	.....	1.00 {Si Cr Mn}	46.00	.....	52.85	.....	0.15C	.....
Others	.....	.....	24.50 to 33.00	.....	66.19 to 74.31	.....	.....	.....
Keene's silver-like alloy	75.00	2.25	16.00	.....	1.50	2.75	0.50Al	2.00
Lutecin or Paris metal of Le Mat	80.00	5.00	16.00	.....	5.00	2.00	.....	1.00
Manganin, has practically no temperature coefficient when used in resistance	82.12	.....	2.29	.....	0.57	.....	.....	15.02Mn
Minargent, 100 parts Cu, 70 parts Ni, 50 parts Sb	45.50	.....	31.80	22.7	.....	.....	.....	.....
Monel metal, approximately	28.00	.....	67.00	.....	5.00 {Fe Co}	.....	.....	.....
Nichrome (U. S. patent 811859; A. L. Marsh)	.....	.....	90.00	.....	.....	.....	10.00Cr	.....
Parker's chromium alloy	60.00	20.00	10.00	10.00Cr	.....	.....	.....	.....
Parr's alloy. Said to have tensile strength of 60,000 pounds per square inch and to resist acids. Also contains Al, B, and Mn	5.00	.....	63.00	2.00W	20.00Cr	.....	5.00Mo	.....
Ruolz alloys:								
For rolling, pressing, and drawing	37.00 to 42.00	.....	25.00 to 30.00	.....	.....	.....	38.00	.....
For jewelry	30.00 to 40.00	.....	20.00 to 30.00	.....	.....	.....	40.00	.....
For casting	45.00 to 55.00	.....	25.00 to 35.00	.....	.....	.....	20.00	.....
For rolling, pressing, and drawing	41.80	16.30	8.60	.....	.....	.....	33.30	.....
For jewelry	44.60	10.80	4.60	.....	.....	.....	40.00	.....
Silverine	71.00 to 79.50	1.00 to 7.50	16.00 to 16.50	.....	1.00 to 1.50	1.00 to 2.75	0.00 to 0.50 Al	1.00 to 2.00
Silver-like alloy, according to Pirsch-Baudoin	71.00	7.00	16.50	.....	1.25	2.50	.....	1.75
Toucas's German silver	35.70	7.10	28.60	7.10	7.20	7.20	7.10Sb	.....
Turbadium bronze; used for propeller castings	48.00	46.45	2.00	0.10	1.00	0.50	0.20Al	1.75Mn
Victor metal; resists salt air	49.94	34.27	15.40	.....	0.28	.....	0.11Al	.....
White copper, Chinese, according to Levol	79.40	.....	16.20	.....	4.58	.....	.....	.....
White copper, Suhl	40.40	25.40	31.60	.....	.....	2.60	.....	.....
Miscellaneous:								
Very suitable for castings, copper 30, tin 17, nickel 10	52.50	.....	17.70	.....	.....	28.80	.....	.....
For bells and bearings, according to Elsner; steel-like with a reddish tinge, capable of taking a high polish, very hard, slightly ductile, of a beautiful sound, not attacked by sulphuretted hydrogen	50.00	.....	25.00	.....	.....	25.00	.....	.....
For mirrors and reflectors, copper 32, tin 15½, nickel 2	64.60	.....	4.10	.....	.....	31.30	.....	.....

Great quantities of nickel are used for plating iron and other articles where a beautiful protective finish is desired.

It seems remarkable that, with its toughness, resistance to corrosion, and good color, pure nickel cooking utensils are not manufactured.

PUBLICATIONS.

The following publications relate to the nickel deposits of the United States. The Survey publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced Survey publications may be purchased from the Superintendent of Documents, Washington, D. C. The other publications listed are not available for distribution by the Survey but may be consulted at the larger libraries of the country.

Bancroft, Howland, Platinum in southeastern Nevada: U. S. Geol. Survey Bull. 430, pp. 192–199, 1910. 60c. Describes nickel deposit at Key West, Nev.

———The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, pp. 30, 182–195, 1914.

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Clarke, F. W., and Diller, J. S., Some nickel ores from Oregon: Am. Jour. Sci., 3d ser., vol. 35, pp. 483–488, 1888.

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Frazer, Persifor, jr., The geology of Lancaster County [Pa.]: Pennsylvania Second Geol. Survey Rept. CCC, pp. 163–171, 1880.

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Kemp, J. F., The nickel mine at Lancaster Gap, Pa., and the pyrrhotite deposits at Anthony's Nose, on the Hudson: Am. Inst. Min. Eng. Trans., vol. 24, pp. 620–633, 1895.

———The ore deposits of the United States and Canada, 3d ed., 481 pp., 1900. Pages 428–441 describe nickel deposits at the Gap mine, Pa.; Sudbury, Ont.; Riddle, Oreg.; and Mine Lamotte, Mo.

Neill, J. M., Notes on the treatment of nickel-cobalt mattes at Mine Lamotte [Mo.]: Am. Inst. Min. Eng. Trans., vol. 13, pp. 634–639, 1885.

Packard, R. L., Genesis of nickel ores: U. S. Geol. Survey Mineral Resources, 1892, pp. 170–177, 1893. 50c.

Ransome, F. L., Notes on some mining districts in Humboldt County, Nev.: U. S. Geol. Survey Bull. 414, pp. 12, 48, 55–58, 1909. Describes nickel and cobalt deposits of Cottonwood Canyon.

Umpleby, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 71–72, 159–165, 1913.

Wharton, Joseph, Analysis of the nickel ore from the Gap mine, Lancaster County, Pa.: Acad. Nat. Sci. Philadelphia Proc., 1870, p. 6.

GOLD AND SILVER.

(GENERAL REPORT.)

By H. D. McCaskey and J. P. Dunlop.

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PRODUCTION.

DOMESTIC PRODUCTION.

The recovered output of gold and silver in the United States from domestic ores and gravels in 1915 is shown below.

Approximate distribution, by producing States and Territories, of the production of gold and silver in the United States for 1915.[a]

State or Territory.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.
Alabama	247	$5,100		
Alaska	808,346	16,710,000	1,054,634	$526,100
Arizona	220,392	4,555,900	5,665,672	2,826,500
California	1,090,731	22,547,400	1,689,924	843,106
Colorado	1,089,927	22,530,800	7,199,745	3,591,900
Georgia	1,683	34,800	141	100
Idaho	56,628	1,170,600	13,042,466	6,506,800
Illinois			3,892	1,900
Michigan			581,874	290,300
Missouri			55,534	27,700
Montana	240,825	4,978,300	14,423,173	7,195,600
Nevada	574,874	11,883,700	14,453,085	7,210,500
New Mexico	70,632	1,460,100	2,337,064	1,165,900
North Carolina	8,258	170,700	1,496	700
Oregon	90,321	1,867,100	125,499	62,600
Philippine Islands	63,898	1,320,900	15,148	7,600
Porto Rico	34	700		
South Carolina	174	3,600		
South Dakota	358,145	7,403,500	197,569	98,600
Tennessee	329	6,800	99,171	49,500
Texas	87	1,800	724,580	361,500
Utah	189,045	3,907,900	13,073,471	6,522,200
Vermont			150	100
Virginia	24	500		
Washington	22,330	461,600	213,877	106,700
Wyoming	672	13,900	2,910	1,400
	4,887,602	101,035,700	74,961,075	37,397,300

[a] Gold value, $20.67+ per fine ounce. Average commercial (dealer's) price of silver 0.999 fine in 1915, 49.9 cents per fine ounce.

The figures in this table result from cooperation of the United States Bureau of the Mint and the United States Geological Survey and are agreed upon after conference and adjustment between the two bureaus. They are, therefore, final for both.

The totals are based on bullion deposits in the United States mints and assay offices and on returns to the Bureau of the Mint from the smelting and refining companies. The distribution is adjusted by information collected by the United States Geological Survey directly from the producing mines and tabulated for the mines reports later discussed. The data giving the total production, and in part the distribution, are obtained from records of (1) the unrefined domestic gold and silver deposited in United States mints and assay offices, (2) the domestic gold and silver in fine bars reported by private refineries, and (3) the unrefined domestic gold and silver contained in ores and matte exported for reduction. The last item is of small relative importance.

Increase and decrease in the production of gold and silver in the several States and outlying possessions, as compared with the output of 1914, are shown in the following table:

Increase or decrease in production of gold and silver in the United States in 1915.

State or Territory.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value
Alabama	− 348	− $7,200	− 300	− $200
Alaska	+ 7,875	+ 162,800	+ 188,734	+ 47,300
Arizona	− 628	− 13,000	+1,226,172	+ 371,500
California	+ 62,670	+1,295,500	− 330,876	− 274,400
Colorado	+ 127,148	+2,628,400	−1,604,655	− 1,276,900
Georgia	+ 870	+ 18,000	+ 41	.....
Idaho	− 803	− 16,600	+ 468,666	− 446,500
Illinois	.....	.....	+ 1,992	+ 700
Maryland	− 10	− 200	− 100	− 100
Michigan	.....	.....	+ 166,374	+ 60,500
Missouri	.....	.....	− 4,466	− 5,500
Montana	+ 40,379	+ 834,700	+1,886,473	+ 262,800
Nevada	+ 16,810	+ 347,500	−1,424,115	− 1,569,600
New Mexico	+ 11,658	+ 241,000	+ 565,764	+ 186,400
North Carolina	+ 1,955	+ 40,400	− 4	− 100
Oklahoma	.....	.....	− 6,200	− 3,400
Oregon	+ 13,434	+ 277,700	− 21,901	− 18,900
Philippine Islands	+ 10,719	+ 221,600	+ 4,848	+ 1,900
Porto Rico	− 101	− 2,100	.....	.....
South Carolina	+ 19	+ 400	.....	.....
South Dakota	+ 3,363	+ 69,500	+ 17,769	− 800
Tennessee	+ 20	+ 400	− 3,629	− 7,300
Texas	− 339	− 7,000	+ 149,880	+ 43,700
Utah	+ 25,683	+ 530,900	+1,351,471	+ 39,900
Vermont	.....	.....	+ 150	+ 100
Virginia	+ 9	+ 200	− 1,500	− 800
Washington	− 6,105	− 126,200	− 127,423	− 82,000
Wyoming	+ 348	+ 7,200	+ 2,810	+ 1,300
Increase or decrease	+ 314,626	+6,503,900	+2,505,975	− 2,670,400

In addition to the production of gold and silver by domestic smelters and refiners from domestic sources in 1915, amounting to 4,887,602 fine ounces of gold and 74,961,075 fine ounces of silver, these plants produced 855,728 fine ounces of gold and 50,987,199 fine ounces of silver from foreign ores. These figures represent in-

creases in all items over the corresponding figures for 1914. The foreign ores producing this bullion are mainly from Mexico and Canada.

PRICES OF SILVER.

The average official monthly prices of fine bar silver in New York in 1915 were as follows:

Price of silver per fine ounce in 1915, by months.[1]

January	$0.50220	August	$0.48524
February	.49886	September	.50030
March	.51616	October	.50790
April	.51596	November	.53104
May	.51255	December	.56435
June	.50452		
July	.48832	Yearly average	.51062

The average annual price of silver per fine ounce from 1865 to 1915, inclusive, has been:

Price of silver per fine ounce, 1865–1915.[2]

1865	$1.337	1891	$0.99
1866	1.339	1892	.87
1867	1.33	1893	.78
1868	1.326	1894	.63
1869	1.325	1895	.65
1870	1.328	1896	.68
1871	1.325	1897	.60
1872	1.322	1898	.59
1873	1.297	1899	.60
1874	1.278	1900	.62
1875	1.24	1901	.60
1876	1.16	1902	.53
1877	1.20	1903	.54
1878	1.15	1904	.58
1879	1.12	1905	.61
1880	1.15	1906	.68
1881	1.13	1907	.66
1882	1.14	1908	.53
1883	1.11	1909	.52
1884	1.11	1910	.54
1885	1.07	1911	.53
1886	.99	1912	.615
1887	.98	1913	.604
1888	.94	1914	.553
1889	.94	1915	.519
1890	1.05		

[1] Report of Director of the Mint, p. 254, 1915. This represents average official quotations for sale by the Mint and is above dealers' prices for silver 0.999 fine.
[2] Based on London price of bar silver 1.000 fine, and taken at average price and par of exchange.

WORLD'S PRODUCTION OF GOLD.

Value of gold produced in the world, 1860–1915.

[The annual production from 1860 to 1872 is obtained from statistics for 5-year periods compiled by Dr. Adolph Soetbeer. Since 1872 the estimates are those of the Bureau of the Mint.]

Calendar year.	Value.	Calendar year.	Value.	Calendar year.	Value.	Calendar year.	Value.
1860	$134,083,000	1875	$97,500,000	1890	$118,848,700	1905	$380,288,700
1861	122,989,000	1876	103,700,000	1891	130,650,000	1906	402,503,000
1862	122,989,000	1877	113,947,200	1892	146,651,500	1907	412,966,600
1863	122,989,000	1878	119,092,800	1893	157,494,800	1908	442,476,900
1864	122,989,000	1879	108,778,800	1894	181,175,600	1909	454,059,100
1865	122,989,000	1880	106,436,800	1895	198,763,600	1910	455,239,100
1866	129,614,000	1881	103,023,100	1896	202,251,600	1911	461,939,700
1867	129,614,000	1882	101,936,600	1897	236,083,700	1912	466,136,100
1868	129,614,000	1883	95,392,000	1898	286,879,700	1913	459,941,100
1869	129,614,000	1884	101,729,600	1899	306,724,100	1914	439,078,278
1870	129,614,000	1885	108,435,600	1900	254,576,300	1915	470,466,214
1871	115,577,000	1886	106,163,900	1901	260,992,900		
1872	115,577,000	1887	105,774,900	1902	296,737,600		11,719,253,492
1873	96,200,000	1888	110,196,900	1903	327,702,700		
1874	90,750,000	1889	123,489,200	1904	347,377,200		

In the following table is shown the output of gold, by countries, as given by the Bureau of the Mint:

World's production of gold, 1904–1915.

Country.	1904	1905	1906	1907	1908	1909
North America:						
United States	$80,464,700	$88,180,700	$94,373,800	$90,435,700	$94,560,000	$99,673,400
Canada	16,462,500	14,610,400	12,023,900	8,382,800	9,482,100	9,382,200
Mexico	12,605,300	16,107,100	18,534,700	18,681,100	22,371,200	23,842,900
Africa	85,913,900	113,254,700	135,358,000	151,984,100	166,520,500	170,988,600
Australasia	87,767,300	85,926,500	82,391,400	75,677,700	73,327,300	71,007,900
Europe:						
Russia and Finland	24,803,200	22,292,200	19,496,500	26,684,300	28,052,200	32,381,300
Austria-Hungary	2,117,300	2,457,400	2,615,400	2,484,900	2,469,300	1,942,000
Germany	64,700	66,700	80,400	66,600	64,800	69,000
Norway						
Sweden	40,200	36,700	13,300	18,700	14,500	10,100
Italy	44,000	44,000	41,200	39,600	46,500	24,200
Spain and Portugal						2,900
Turkey	29,000	6,000	6,000	4,500	2,200	500
France			502,400	835,400	1,147,400	1,400,000
Great Britain	359,800	112,700	29,200	29,200	16,000	21,500
Serbia			59,800	59,800	59,800	150,300
South America:						
Argentina	9,200	5,500	5,500	103,000	161,300	189,900
Bolivia	21,900	18,800	754,600	1,267,400	346,300	492,400
Chile	636,900	948,500				
Colombia	1,974,400	2,584,000	2,190,800	3,255,600	3,427,300	3,179,900
Ecuador	132,900	188,500	294,200	267,100	350,300	274,400
Brazil	2,043,500	2,044,600	2,403,000	2,020,700	2,196,600	2,252,900
Venezuela	300,000	171,400	25,300	22,400	24,500	280,600
Guiana—						
British	1,608,800	1,690,700	1,607,700	1,304,400	1,408,100	1,192,700
Dutch	441,600	632,500	689,200	640,000	663,000	621,000
French	1,806,400	1,859,700	1,858,900	2,360,800	2,135,500	2,143,800
Peru	1,329,200	516,100	829,000	514,500	514,500	514,500
Uruguay	25,000	50,000	31,700	51,900	91,600	91,600
Central America	1,252,500	1,513,400	1,910,700	2,107,800	3,018,800	2,630,100
Asia:						
Japan	2,948,200	3,072,400	2,748,900	2,773,000	3,321,600	3,616,900
China	4,500,000	4,500,000	4,500,000	4,500,000	8,647,300	9,352,100
Indo-China				31,800	65,600	65,600
Chosen (Korea)	3,000,000	2,593,000	2,283,000	2,170,800	3,047,500	1,993,600
Siam	51,800	48,600	53,200	166,200	327,600	327,600
India, British	11,722,900	11,950,200	12,087,700	10,383,600	10,598,500	10,358,600
East Indies, British	1,485,300	1,391,000	1,448,700	1,561,300	1,400,900	1,436,900
East Indies, Dutch	1,414,500	1,414,500	1,254,900	2,079,900	2,596,300	2,146,400
	347,377,200	380,288,700	402,503,000	412,966,600	442,476,900	454,059,100

World's production of gold, 1904–1915—Continued.

Country.	1910	1911	1912	1913	1914	1915
North America:						
United States	$96,269,100	$96,890,000	$93,451,500	$88,884,400	$94,531,800	$101,035,700
Canada	10,205,800	9,762,100	12,648,800	16,598,900	15,983,004	18,936,971
Mexico	24,910,600	24,880,100	24,500,000	19,308,800	4,788,175	6,559,275
Cuba	.....	20,000	.....	.....	.....	.....
Africa	175,189,900	191,538,400	211,850,600	207,326,500	201,996,796	217,639,599
Australasia	65,470,600	60,184,200	54,509,400	53,113,200	47,569,023	49,397,797
Europe:						
Russia and Finland	35,579,600	32,151,600	22,199,000	26,508,700	28,586,392	28,586,392
Austria-Hungary	2,172,600	2,185,100	2,043,200	2,179,300	200,744	200,744
Germany	62,900	78,100	78,100	135,600	.....	.....
Norway	1,400	.....	.....	.....	.....	.....
Sweden	2,000	2,000	20,300	17,600	54,304	22,532
Italy	29,600	44,800	11,000	17,200	32,145	2,295
Spain and Portugal	2,800	2,400	2,300	2,300	2,336	661
Turkey	500	500	500	500	475	475
France	1,707,100	1,812,100	1,812,100	2,127,400	1,400,000	1,400,000
Great Britain	39,600	39,600	27,800	17,900	20,238	19,266
Serbia	.....	251,100	251,100	328,000	116,000	.....
South America:						
Argentina	173,100	289,000	107,300	2,600	.....	.....
Bolivia and Chile	463,600	362,500	175,000	175,000	202,770	814,418
Colombia	3,370,000	3,167,800	2,971,700	2,971,700	4,678,587	5,453,148
Ecuador	249,200	276,800	496,500	496,500	346,853	545,674
Brazil	1,954,700	3,834,500	3,570,600	2,254,700	2,139,803	2,421,515
Venezuela	340,500	364,800	623,500	444,800	612,796	612,796
Guiana:						
British	1,192,700	892,000	879,800	1,353,500	1,126,500	923,892
Dutch	792,600	523,400	407,300	470,400	503,490	449,054
French	2,229,100	2,229,100	3,050,600	3,050,600	1,959,793	1,959,793
Peru	455,900	492,300	492,200	492,300	1,022,125	1,109,891
Uruguay	91,600	70,600	111,000	29,900	15,276	11,836
Central America	4,657,400	3,360,400	3,030,400	2,721,700	2,393,190	2,970,271
Asia:						
Japan	3,903,600	4,118,600	4,467,000	3,614,400	4,679,358	5,385,917
China	3,658,100	3,314,600	3,658,900	3,658,900	3,658,900	2,804,692
Indo-China	55,000	74,700	74,700	74,700	66,419	43,659
Chosen (Korea)	4,399,100	2,889,400	2,852,600	3,582,500	3,309,870	3,739,477
Siam	56,500	56,500	56,500	56,500	.....	.....
India, British	10,718,400	11,054,100	11,055,700	12,178,000	11,378,400	11,522,457
East Indies, British	1,416,800	1,339,400	1,352,000	1,352,000	4,480,853	4,398,476
East Indies, Dutch	3,387,100	3,387,100	3,387,100	3,387,100		
Federated Malay States	.....	.....	.....	282,400	269,147	351,524
Formosa	.....	.....	.....	814,600	952,806	1,143,017
	455,239,100	461,939,700	466,136,100	459,941,100	439,078,278	470,466,214

Owing to the difficulty of obtaining accurate statistics since the beginning of the European war, estimates have been made for 1914 and 1915 for some foreign countries, and for a few others, from lack of basis for estimates, the figures for preceding years have been repeated.

The figures given for the years 1904 to 1912, inclusive, are from the reports of the Director of the Mint. The statistics for 1913 to 1915, inclusive, were adjusted in conferences between the Mint and the Geological Survey.

The notable increase of total world's output of gold culminated in a new record of $470,466,214 in 1915, following a decline from the previous record of $466,136,100 in 1912 to $439,078,278 in 1914. The principal gains for 1915 as compared with 1914 are shown below.

Increase in gold output in 1915.

Country.	1914	1915	Increase.
United States	$94,531,800	$101,035,700	$6,503,900
Canada	15,983,004	18,936,971	2,953,967
Mexico	4,788,175	6,559,275	1,771,100
New Zealand	4,712,226	8,740,567	4,028,341
Rhodesia	17,663,686	18,915,324	1,251,638
Transvaal, Cape Colony, and Natal	173,559,940	188,033,156	14,473,216

A survey of the record for the last decade shows the notably increasing total output of Africa, chiefly from the great mines of the Rand; the frequent fluctuations of the important contributions from the United States and Russia; the continued decline in Australasia, arrested, however, in 1915, chiefly by the increase noted for New Zealand; and the fairly constant output from British India and many other countries.

PRODUCTION OF GOLD AND SILVER SINCE 1792.

According to tables published by the Director of the Mint, the total production of gold and silver in the United States is as follows:

Gold and silver produced in the United States, 1792–1915.

[The estimate for 1792-1872 is by R. W. Raymond, commissioner, and since by the Director of the Mint.]

Period.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.
1792–1847	1,187,170	$24,537,000	309,500	$404,500
1848–1872	58,279,778	1,204,750,000	118,568,200	157,749,900
1873–1915	121,280,081	2,507,079,900	2,114,504,575	1,628,828,200
	180,747,029	3,736,366,900	2,233,382,275	1,786,982,600

Gold and silver produced in the United States, 1880–1915.

Year.	Gold.		Silver.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Commercial value.
1880	1,741,500	$36,000,000	30,318,700	$34,717,000
1881	1,678,612	34,700,000	33,257,800	37,657,500
1882	1,572,187	32,500,000	36,196,900	41,105,900
1883	1,451,250	30,000,000	35,732,800	39,618,400
1884	1,489,950	30,800,000	37,743,800	41,921,300
1885	1,538,373	31,801,000	39,909,400	42,503,500
1886	1,686,788	34,869,000	39,694,000	39,482,400
1887	1,603,049	33,136,000	41,721,600	40,887,200
1888	1,604,478	33,167,500	45,792,700	43,045,100
1889	1,594,775	32,967,000	50,094,500	46,838,400
1890	1,588,877	32,845,000	54,516,300	57,242,100
1891	1,604,840	33,175,000	58,330,000	57,630,000
1892	1,597,098	33,015,000	63,500,000	55,662,500
1893	1,739,323	35,955,000	60,000,000	46,800,000
1894	1,910,813	39,500,000	49,500,000	31,422,100
1895	2,254,760	46,610,000	55,727,000	36,445,500
1896	2,568,132	53,088,000	58,834,800	39,654,600
1897	2,774,935	57,363,000	53,860,000	32,316,000
1898	3,118,398	64,463,000	54,438,000	32,118,400
1899	3,437,210	71,053,400	54,764,500	32,858,700
1900	3,829,897	79,191,000	57,647,000	35,741,100
1901	3,805,500	78,666,700	55,214,000	33,128,400
1902	3,870,000	80,000,000	55,500,000	29,415,000
1903	3,560,000	73,591,700	54,300,000	29,322,000
1904	3,892,480	80,464,700	57,682,800	33,456,000
1905	4,265,742	88,180,700	56,101,600	34,222,000
1906	4,565,333	94,373,800	56,517,900	38,256,400
1907	4,374,827	90,435,700	56,514,700	37,299,700
1908	4,574,340	94,560,000	52,440,800	28,050,600
1909	4,821,701	99,673,400	54,721,500	28,455,200
1910	4,657,018	96,269,100	57,137,900	30,854,500
1911	4,687,053	96,890,000	60,399,400	32,615,700
1912	4,520,717	93,451,500	63,766,800	39,197,500
1913	4,299,783	88,884,400	66,801,500	40,348,100
1914	4,572,976	94,531,800	72,455,100	40,067,700
1915	4,887,602	101,035,700	74,961,075	37,397,300
	107,740,317	2,227,188,100	1,906,094,875	1,377,753,800

IMPORTS AND EXPORTS.

Value of gold and silver imported and exported, 1915.

[Figures furnished by the Bureau of Foreign and Domestic Commerce.]

Metal.	Imports.	Exports.	Excess of—	
			Imports.	Exports.
GOLD.				
Contained in domestic ore and base bullion		$419,330		$419,330
Contained in foreign ore and base bullion	$13,651,768		$13,651,768	
Domestic bullion refined	13,081,059	838,095	12,242,964	
Foreign bullion refined	39,032,507	973,995	38,058,512	
United States coin	156,564,421	17,095,212	139,469,209	
Foreign coin	229,624,835	12,099,286	217,525,549	
	451,954,590	31,425,918	420,948,002	419,330
Excess	420,528,672		420,528,672	
SILVER.				
Contained in domestic ore and base bullion		63,628		63,628
Contained in foreign ore and base bullion	8,108,163		8,108,163	
Domestic bullion refined	756,910	278,029	478,881	
Foreign bullion refined	22,977,399	49,619,660		26,642,261
United States coin	1,349,130	157,159	1,191,971	
Foreign coin	1,292,352	3,480,408		2,188,056
	34,483,954	53,598,884	9,779,015	28,893,945
Excess		19,114,930		19,114,930

The remarkable gain in domestic supply of gold indicated by the great excess of $420,500,000 in imports over exports for 1915, an excess equivalent to nearly 90 per cent of the total world's output of new gold for the year, was due to the rôle of creditor nation maintained by this country since the last great movements of its gold abroad. The continuation of large exports of silver to the Far East and especially to the Entente nations in Europe was due in part to demand for the coinage of silver money for troops in the field.

MINES REPORT.

METHOD OF COLLECTING STATISTICS.

The first table in this report presents the final official figures of the production of gold and silver in the United States in 1915 as agreed upon by the Bureau of the Mint and the United States Geological Survey. With the comparatively unimportant exceptions of domestic gold and silver contained in ores and mattes exported for reduction during the year, these figures record the actual production of gold and silver bullion from domestic ores in marketable form as metals, either refined or unrefined.

Owing to the difficulty of tracing this total gold and silver production back to its origin by States, counties, and mining districts, however, the Geological Survey attacks this problem of distribution by systematic investigation of the mine production of ores containing gold and silver during the calendar year and of the output of the placer mines. In this way the state of the mining industry is studied in detail, and classification of output by methods of production and by kinds of ore, as well as by mining districts, is obtained. The resulting figures form the basis of the mines report.

Of the two plans outlined for ascertaining the gold and silver production of the United States it may be said that the one is a measure of the mining industry and the other a measure of the metallurgical industry; and one reports the production and recoverable content of mine output and the other the metal actually recovered in marketable form. The two methods will not produce exactly corresponding results, nor should they be expected to do so.

The figures of the reports of the Mint and of the mines reports for a period of years sufficiently long to compensate for overlap or lag should agree within allowable limits of error due to the complex problem involved.

For the last 11 years in which complete statistics have been gathered by both methods the final figures have been as follows:

Production of gold and silver, 1905–1915, according to Mint and to mine returns.

Year.	Mint.		Mine.	
	Gold.	Silver.	Gold.	Silver.
		Ounces.		*Ounces.*
1905	$88,180,700	56,101,600	$88,159,881	56,272,496
1906	94,373,800	56,517,900	97,219,645	57,362,455
1907	90,435,700	56,514,700	87,471,136	52,500,104
1908	94,560,000	52,440,800	91,914,891	50,878,140
1909	99,673,400	54,721,500	99,438,144	57,315,677
1910	96,269,100	57,137,900	94,933,778	57,598,509
1911	96,890,000	60,399,400	97,054,791	61,108,791
1912	93,451,500	63,766,800	92,880,467	66,041,506
1913	88,884,400	66,801,500	89,987,888	71,200,237
1914	94,531,800	72,455,100	92,703,757	69,633,769
1915	101,035,700	74,961,075	99,605,314	72,368,878
	1,038,285,700	671,818,275	1,031,369,692	672,280,562

These figures show, according to Mint reports, a total excess of gold for the 11 years of $6,916,008, or a difference of not quite 0.7 per cent, and a total deficit of silver of only 462,287 ounces, or a difference less than 0.1 per cent. The figures for Alaska placers are not considered to be so closely approximate as the above agreement for gold, hence the differences for the United States proper are probably even lower. It is thought that those small differences are fully accounted for in the detailed discussions of the subject in previous reports of this series. For figures of any one year an excess of mining over smelting and refining is indicated by larger returns in the mines reports for gold or silver or both, and opposite relations or excess of smelting and refining and drawing upon stocks is suggested by reverse figures.

UNITS OF MEASUREMENT.

In measurement of ores and concentrates the short ton of 2,000 pounds is used throughout. The price of gold is fixed by law at $20.67+ per fine ounce. The annual average prices for silver from 1865 to 1915, inclusive, based on the equivalent New York value of a fine ounce with exchange at par, are given elsewhere in this report. The average commercial prices (or dealers' prices) for silver 0.999 fine at New York are those quoted from day to day on the market and run uniformly somewhat below the prices as given elsewhere by years.

PRODUCTION OF GOLD AND SILVER REPORTED FROM THE MINES.

The following table gives the quantity and value of recoverable gold and silver output (mine production) by States reported from the producing mines in 1915 to the United States Geological Survey. The increase or decrease of production shows results by comparison with the corresponding Survey mine figures for 1914.

Mine production of gold and silver in the United States in 1915.

State or Territory.	Gold.		Silver.		Increase or decrease.	
	Quantity (fine ounces).	Value.	Quantity (fine ounces).	Value.	Gold.	Silver (fine ounces).
Alabama	253.63	$5,243	12	$6	− $6,727	− 187
Alaska	807,966.22	16,702,144	1,071,782	543,393	+ 937,885	+ 676,977
Arizona	201,531.46	4,166,025	5,649,020	2,864,053	− 13,130	+1,271,026
California	1,085,646.07	22,442,296	1,678,756	851,129	+1,788,800	+ 206,897
Colorado	1,084,322.91	22,414,944	7,027,972	3,563,182	+2,531,839	−1,768,093
Georgia	1,732.84	35,821	138	70	+ 19,551	+ 71
Idaho	57,069.49	1,179,731	11,769,128	5,966,948	+ 27,416	− 710,388
Illinois			3,864	1,959		+ 1,752
Maryland and Pennsylvania					− 225	− 44
Michigan			585,933	297,068		+ 172,433
Missouri			57,756	29,282		− 3,412
Montana	242,077.93	5,004,195	14,378,437	7,289,868	+ 886,284	+2,361,977
Nevada	551,683.01	11,404,300	14,459,840	7,331,139	− 76,888	− 995,651
New Mexico	70,680.96	1,461,105	2,005,531	1,016,804	+ 289,409	+ 228,086
North Carolina	8,320.55	172,001	1,465	743	+ 40,860	− 59
Oklahoma						− 6,187
Oregon	90,064.38	1,861,796	117,947	59,799	+ 270,335	− 24,605
Philippines	63,898.54	1,320,900	15,148	7,680	− 50,614	+ 4,648
Porto Rico	33.86	700			− 2,100	− 20
South Carolina	183.29	3,789	8	4	− 3,571	− 25
South Dakota	358,280.00	7,406,305	199,864	101,331	+ 72,797	+ 23,222
Tennessee	331.95	6,862	100,543	50,975	+ 668	+ 3,141
Texas	72.71	1,503	675,473	342,465	+ 1,269	+ 144,656
Utah	174,590.65	3,609,109	12,313,205	6,242,795	+ 343,762	+1,158,289
Vermont			379	192		+ 379
Virginia	25.83	534			+ 105	− 1,458
Washington	18,934.90	391,419	255,837	129,709	− 165,754	− 9,024
Wisconsin						− 16
Wyoming	705.89	14,592	840	426	+ 9,586	+ 724
Total	4,818,407.07	99,605,314	72,368,878	36,691,020	+6,901,557	+2,735,109
Increase or decrease in value					+6,901,557	−$1,816,454

An increase in production of gold from mines of the United States of $6,901,557 is shown for 1915, following an increase of $2,715,869 for the preceding year. An increase of 2,735,109 ounces of silver is also shown, following a decrease of 1,566,468 ounces in 1914.

The principal gold-producing States ranked as follows in 1915: California, Colorado, Alaska, Nevada, and South Dakota, and these five States together made nearly 81 per cent of the total output. The most notable increases in gold were $2,531,839 in Colorado, $1,788,800 in California, $937,885 in Alaska, and $886,284 in Montana.

The principal silver-producing States in 1915 in order of output were Nevada, Montana, Utah, Idaho, Colorado, and Arizona, and these six States together produced more than 90 per cent of the total for the United States. The largest increases for 1915 were 2,361,977 ounces in Montana, 1,271,026 ounces in Arizona, and 1,158,289 ounces in Utah. Large decreases of silver are noted of 1,768,093 ounces in Colorado, 995,651 ounces in Nevada, and 710,388 ounces in Idaho.

MINE PRODUCTION OF GOLD AND SILVER BY STATES.

ALASKA.

It is estimated by A. H. Brooks that the total yield of gold from Alaska from earliest mining, in 1880, to the end of 1915, has been $260,858,943, of which $186,192,992 has come from placers. The total silver production has been 4,923,198 fine ounces, of which 2,360,187 ounces was recovered from copper ores and 1,576,823 ounces from the refining of placer gold.[1]

Gold.—The mine production of gold in Alaska in 1915 was $16, 702, 144, an increase of nearly $1,000,000 more than that of 1914. The yield from siliceous ores increased from $4,863,028 in 1914 to $6,069,023 in 1915; the yield from copper ores decreased from $171,231 in 1914 to $153,121 in 1915. The placer output in 1915 was $10,480,000, against $10,730,000 in 1914. Thirty-five dredges produced $2,330,000 of the placer gold, which was $20,000 less than the yield from dredging in 1914.

The production of gold from the Yukon and Kuskokwim basins in 1915 was about $500,000 less than in 1914; but the output from southeastern Alaska and Prince William Sound region increased about $1,300,000, that from Copper River and Cook Inlet regions increased $7,700, and that from Seward Peninsula and northwestern Alaska increased $185,000. Of the productive gold lode mines 13 were in southeastern Alaska, 5 on Prince William Sound, 4 in Kenai Peninsula, 3 in Willow Creek district, and 3 in Fairbanks district. The 13 deep gold mines in southeastern Alaska yielded nearly 90 per cent of the gold derived from siliceous ores.

In 1915 the average value of the gold and silver content of all the siliceous ores treated was $2.79 a ton. The 3,020,607 tons of siliceous ores treated in 1915 yielded $2.02 in gold and silver a ton and the 369,600 tons of copper ore contained $1.65 in gold and silver a ton and had a copper content of 11.7 per cent.

About 38 per cent of the total gold output of Alaska came from lode mines in 1915, against 32 per cent in 1914, 31.6 per cent in 1913, and 29 per cent in 1912, indicating a more accelerated transition from placer to lode mining. The 700 placers operated in 1915 yielded approximately 8,100,000 cubic yards of auriferous gravel, of which the dredges handled about 4,600,000 cubic yards and made an average recovery of 51 cents a yard in 1915, against 52 cents a yard in 1914. The estimated total recovery of gold by dredging for the period 1903–1915, inclusive, is $12,430,894.

No new placer districts were discovered in 1915, though new ground was opened in regions previously known to be gold bearing.

Silver.—The mine production of silver in Alaska in 1915 was 1,071,782 fine ounces, against 394,805 ounces in 1914. The copper mines produced 897,839 ounces, an increase of 614,484 ounces. The siliceous ores yielded 91,341 ounces in 1915, against 28,254 ounces in 1914, and the placers 82,602 ounces in 1915, against 83,196 ounces in 1914.

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[1] U. S. Geol. Survey Mineral Resources, 1915, pt. 1, p. 179, 1916.

ARIZONA.

Gold.—The mine production of gold in Arizona in 1915 was $4,166,025, which was $13,130 less than in 1914. Placers contributed only $35,248, most of which came from small mines in Yuma and Yavapai counties. The deep mines produced $4,130,777, of which 52 per cent came from dry or siliceous ores mined chiefly in Mohave, Maricopa, and Cochise counties, and 43 per cent was contained in copper ores mined chiefly in Cochise and Yavapai counties. Mohave County had a gold output of $1,626,437, Cochise County $1,223,882, and Yavapai County $791,884. The gold recovered from ores treated at gold and silver mills represented 46 per cent of the total output and crude ores shipped to smelters contained nearly 44 per cent. The crude copper ores mined and smelted directly (without previous concentration) contained an average gold content of 65 cents a ton.

Silver.—The mine production of silver increased from 4,377,994 fine ounces in 1914 to 5,649,020 ounces in 1915. Of this production 4,010,510 ounces came from copper ores, 994,184 ounces from dry or siliceous ores, 393,444 ounces from lead ores, 172,103 ounces from lead-zinc ores, and smaller quantities from zinc and copper-lead ores. Cochise County produced 3,034,714 ounces in 1915, of which 1,842,559 ounces came from copper ores and 865,215 ounces from siliceous ores. The silver output of Yavapai County, which increased from 786,917 ounces in 1914 to 1,343,363 ounces in 1915 was nearly all derived from copper ores. Bullion recovered from gold and silver ores, almost all by cyanidation, yielded 741,578 ounces of silver. Concentrates contained 910,138 ounces and crude ore shipped to smelters contained 3,945,730 ounces, or more than 69 per cent of the total output of silver.

CALIFORNIA.

Gold.—The mine production of gold in California in 1915, $22,442,296, was the largest in 33 years, and with the exception of 1883 it was larger than for any year since 1864. The increased yield of $1,788,800 was due to deep-mining operations.

In 1915 the deep mines produced $13,833,679 (an increase of $2,261,032), of which gold-quartz ores yielded 96.2 per cent and copper ores 3.5 per cent. California placers in 1915 yielded $8,608,617 in gold, or $472,232 less than in 1914. Of the placer production $420,770 was recovered by hydraulic mining, $272,955 by drift mining, $118,427 by sluicing, and $7,796,465 by dredging. The total dredge production from 1898 to the end of 1915 has been $79,104,231 and the yield of gold by dredges was equal to 35 per cent of the total yield of gold for 1915. The Yuba County dredges, 12 in number, made the largest output of gold, the value being $2,676,090, a decrease of $79,644. Sacramento County, with 11 dredges working, made an output of $2,129,787, a decrease of $31,866. In Butte County (including Oroville and other districts) 17 dredges produced $1,491,066 in gold, or $146,959 less than in 1914. Dredges were also operated in Calaveras, Eldorado, Merced, Stanislaus, Placer, Shasta, Siskiyou, and Trinity counties.

Eight of the 30 counties in California which reported mine production of gold had a yield of more than $1,000,000 in 1915, as follows: Amador, $3,894,125; Nevada, $3,466,722; Yuba, $2,703,710; Sacramento, $2,131,813; Butte, $1,545,976; Calaveras, $1,391,134; Shasta, $1,120,848; and Tuolumne, $1,058,103. Of these, Yuba, Sacramento, and Butte counties obtained most of their yield by dredging; Amador, Calaveras, and Tuolumne counties are on the Mother Lode; Shasta County produced both siliceous and copper ores; and the Nevada County production was mainly from siliceous ores of the Grass Valley district. The five Mother Lode counties—Amador, Calaveras, Eldorado, Mariposa, and Tuolumne—whose output is mainly gold milling ores, produced $4,059,435 in gold from mill bullion and $2,249,989 from concentrates in 1915, against a recovery of $3,235,116 from mill bullion and $1,809,682 from concentrates in 1914.

Silver.—The mine production of silver in California in 1915 was 1,678,756 fine ounces, an increase of 206,897 ounces. More than half the output, or 860,057 ounces, came from the copper ores of Shasta County. Copper ores from Calaveras, Placer, Plumas, and other counties yielded 196,838 ounces. Zinc ores yielded 114,682 ounces, siliceous ores 272,849 ounces, lead ores 127,958 ounces, and silver ores, silver-lead ores, and placers the remainder. The only counties producing more than 100,000 ounces of silver in 1915 were Shasta, Inyo, San Bernardino, and Calaveras. More than 86 per cent of all the silver was recovered from crude ores sent to smelters.

COLORADO.

Gold.—The total mine production of gold in Colorado in 1915 was $22,414,944, an increase of $2,531,839. This yield was the largest since 1908. The Cripple Creek district, with an increase of $1,687,378, produced $13,683,494 in gold, which was 61 per cent of the State output of gold from all sources. During 1915 the Roosevelt tunnel was driven 1,920 feet. The total recession of water was 149 feet, and the water discharged was equal to about 37,000,000 gallons per vertical foot.

The San Juan region, in Dolores, La Plata, Ouray, San Juan, and San Miguel counties produced $3,854,521, a decrease of $115,336. Lake County yielded $2,246,152, an increase of $674,701, and there were also good increases in Boulder, Clear Creek, Eagle, Park, Gunnison, and San Juan counties. There was a reduced output of gold from La Plata, Ouray, San Miguel, Chaffee, and Gilpin counties. Siliceous and dry ores, which amounted to 80 per cent of all the ore sold or treated, yielded 94 per cent of the total output of gold. Only 2 per cent came from lead ores, 3 per cent from placers, and about 1 per cent from other classes of ore. The placer production in 1915 was $693,310, an increase of $50,950. Summit County produced nearly 88 per cent and Lake County 10 per cent of the placer gold. More than 99 per cent of the placer gold from these two counties was recovered by dredges.

Silver.—The mine production of silver in Colorado in 1915 was 7,027,972 fine ounces, a decrease of 1,768,093 ounces. Lake County, principally Leadville, produced 2,571,002 ounces, a decrease of 1,239,828 ounces. San Miguel County produced 1,096,641 ounces, a

decrease of 183,820 ounces. There was also a decreased output from San Juan, Boulder, Chaffee, Gilpin, Gunnison, La Plata, Ouray, Park, and Saguache counties. Considerably increased outputs came from Clear Creek, Custer, Dolores, Eagle, and Pitkin counties.

Siliceous and dry ores yielded 74 per cent of the silver recovered, lead ores 14 per cent, lead-zinc ores nearly 8 per cent, and copper ores 3 per cent.

IDAHO.

Gold.—The mine production of gold from Idaho in 1915 was $1,179,731, an increase of $27,416. The total production of gold from Idaho from the discovery of placer gold in 1863 to the end of 1915 is estimated at $128,990,350 by C. N. Gerry.[1]

Boise and Lemhi counties continued to be the largest producers of gold, yielding more than 62 per cent of the total output. The lode mines produced gold valued at $594,841. The placer mines produced $584,890 in gold in 1915, of which $486,541, or 83 per cent, was won by dredging. The total output of gold recovered by dredges from 1897 to the end of 1915 has been $3,394,360. Of the total gold in 1915 nearly 50 per cent came from placers, 38 per cent from siliceous ores, 7 per cent from copper ores, and the remainder from lead and lead-zinc ores.

Silver.—The mine production of silver from Idaho in 1915 was 11,769,128 fine ounces, or 710,388 ounces less than in 1914. The total yield of silver from Idaho for the period 1863 to 1915, inclusive, is 200,375,744 fine ounces.[1]

There was a large decrease in the silver output from Shoshone County, which yielded 95 per cent of the total quantity of silver in 1915, against 98 per cent in 1914. Lead ores contained 83 per cent of the output of silver and lead-zinc ores 13 per cent. Crude ore shipped, which averaged 18.64 ounces of silver a ton, supplied nearly 73 per cent of the silver, and concentrates, which averaged 25.46 ounces of silver a ton, contained more than 26 per cent of the total silver. Difficulties in renewing smelter contracts at former rates had the effect of curtailing the production of silver.

MARYLAND, PENNSYLVANIA, NEW HAMPSHIRE, AND VERMONT.

There was no production of gold or silver reported by mines in Maryland and Pennsylvania in 1915, although work was done on prospects in Montgomery County, Md., and copper-bearing concentrates continued to be shipped from the Cornwall magnetite mines at Lebanon, Pa.

There was no active mining in New Hampshire, but some concentrates containing silver, lead, and zinc were recovered from old tailings at the West Ossipee mines in Carroll County.

The Pike Hill mines in Orange County, Vt., were reopened in 1915, and a small quantity of ore carrying copper and silver was treated.

[1] U. S. Geol. Survey Mineral Resources, 1914, pt. 1, p. 598, 1915.

MICHIGAN.

Silver.—The copper mines of Michigan produced 585,933 fine ounces of silver in 1915, against 413,500 ounces in 1914. The silver was mainly derived from the electrolytic treatment of 52,509,000 pounds of copper. The average recovery of silver per ton of "rock" treated was 0.29 ounce a ton. Of the total output of silver 511,224 ounces came from mines in Houghton County.

MISSOURI, OKLAHOMA, ILLINOIS, KENTUCKY, AND WISCONSIN.

Silver.—The lead and zinc mines of the Central States produce no gold and only a comparatively small quantity of silver. Nearly all the silver is a by-product from the refining of lead from concentrates of lead ores mined in southeastern Missouri. The total yield of silver from Missouri in 1915 was 57,756 fine ounces, which, with the exception of a few ounces recovered from copper matte shipped from the Missouri Copper Mountain mine, was derived from lead recovered from 64,377 tons of galena concentrates. The average recovery was slightly less than an ounce of silver per ton of concentrates smelted.

The lead-zinc fluorspar deposits of the Kentucky-Illinois field carry silver and from the lead concentrates shipped from Illinois in 1915 a recovery of 3,864 ounces was recorded, against 2,112 ounces in 1914. The average silver content per ton recovered from lead concentrates from Illinois in 1915 was 6.03 ounces.

MONTANA.

Gold.—The mine production of gold in Montana increased from $4,117,911 in 1914 to $5,004,195 in 1915. The placer yield was $949,248, or about the same as in 1914, so that the increased output was due to the lode mines. Madison County had the largest output, $1,137,012, of which $862,719 came from placer mines. Most of the placer gold was recovered by one company which operated 4 dredges in Alder Gulch and handled about 6,000,000 cubic yards of gravel. Deer Lodge County produced $871,864 chiefly from siliceous ores and Silver Bow County $809,314 mainly from the smelting of concentrates from the Butte copper mines. At amalgamation and cyanidation plants $1,190,934 in gold was produced, or an average recovery of $3.32 per ton of ore and tailings treated. Ore treated at concentration mills yielded concentrates containing $687,630, or 41 cents a ton, and crude ore shipped to smelters contained $2,173,743 in gold, or an average of $3 a ton.

Silver.—Montana mines produced 14,378,437 fine ounces of silver in 1915, a production nearly 20 per cent larger than that of 1914. The copper ores yielded 8,819,772 ounces (an average of 1.81 ounces per ton), of which Silver Bow County (Butte) supplied 8,809,600 ounces. The lead-zinc ores produced 2,768,976 ounces, of which Silver Bow County supplied 2,649,388 ounces and Mineral County 114,265 ounces. The dry or siliceous ores produced 1,635,221 ounces, of which Granite County supplied 802,763 ounces. All of the silver from zinc ore, 734,798 ounces, came from Silver Bow County.

NEVADA.

Gold.—The mine production of gold in Nevada in 1915 was $11,404,300, against $11,481,188 in 1914. The production in 1915 from mines in Esmeralda County was $4,689,260, a decrease of more than $537,000. The Goldfield district yielded $4,389,385 in gold in 1915, against $4,705,210 in 1914. Nye County produced $2,956,380, of which Tonopah yielded $2,228,983. The counties having a substantial increase in gold were Mineral, White Pine, Humboldt, and Clark. The increased output of these counties was almost equal to the large decreases in the production from the Goldfield and Tonopah districts.

Silver.—There was a decrease in the production of silver in Nevada in 1915, the total production being 14,459,840 fine ounces, against 15,455,491 ounces in 1914. Nye County (almost wholly from the Tonopah district) again led in output with 10,220,018 ounces, which was about 1,200,000 ounces less than in 1914. Churchill County, with 1,620,573 ounces, and Humboldt County, with 740,560 ounces, were the other counties which had an output exceeding 500,000 ounces. Dry or siliceous ores yielded all but 650,928 ounces of the output of silver, and 90 per cent of this yield was recovered by cyanidation.

NEW MEXICO.

Gold.—The mine production of gold in New Mexico in 1915 was $1,461,105, against $1,171,696 in 1914 and $881,926 in 1913. Socorro County produced $509,653, or 35 per cent of the State output (this was almost entirely from siliceous ores of the Mogollon district); Grant County, $365,083, or 25 per cent of the total; and Colfax county, $353,376, or 24 per cent of the total.

Copper ores, chiefly from Grant County, contained $376,662, and dry and siliceous ores yielded $1,067,904. The output from other kinds of ore was very small and the placer output was only $9,242.

Silver.—The mine production of silver in New Mexico increased from 1,777,445 fine ounces in 1914 to 2,005,531 ounces in 1915. Socorro County produced 1,358,000 fine ounces, or 68 per cent, chiefly from siliceous ores from the Mogollon district, the remainder from mixed ores of the Magdalena district. The output of silver from Grant County increased from 304,679 fine ounces in 1914 to 508,552 ounces in 1915, and most of this yield came from the Lordsburg district. Dry and siliceous gold and silver ores, chiefly from Grant and Socorro counties, yielded 71 per cent of the total; copper ores, chiefly from Grant, Socorro, and Santa Fe counties, yielded nearly 26 per cent. The remainder of the production was from lead and copper-lead ores, mainly from the Magdalena district.

OREGON.

Gold.—The mine production of gold from Oregon increased 17 per cent, being $1,861,796 in 1915, against $1,591,461 in 1914. The output in 1915 was the largest recorded by the Survey for 12 years. The increase was due entirely to the deep mines, which yielded $1,379,626, or $336,482 more in 1915 that in 1914. The output

from deep mines was almost entirely from siliceous ores. The placer mines of the State produced $482,170, a decrease of $66,147. Of the placer output the hydraulic mines yielded $115,013, or $63,886 less than in 1914. The two dredges in the Cracker Creek district in Baker County and a few drift mines and surface placers in Baker, Jackson, Crook, Josephine, and Malheur counties produced the remainder of the placer gold. Baker County, with a yield of $1,685,382, was the only county which produced more than $100,000 in gold.

Silver.—The mine production of silver in Oregon in 1915 was 117,947 fine ounces, a decrease of 24,605 ounces. Of the total production 99,264 ounces came from siliceous ores, 9,807 ounces from copper ores, and 3,349 ounces from lead ores.

SOUTH DAKOTA.

The total value of the production of gold in South Dakota from 1876 to the end of 1915 is given by Charles W. Henderson, of the United States Geological Survey, as $192,693,945, and the total output of silver for the same period as 6,032,533 fine ounces.[1]

Gold.—The mine production of gold in South Dakota in 1915 was $7,406,305, against $7,333,508 in 1914. The output was almost wholly from siliceous milling ores of low grade, of which about 64 per cent was recovered by amalgamation and the remainder by cyanidation. The Homestake mines and mills were operated continuously and produced $6,428,786 in bullion from 1,573,822 tons of ore treated. The Golden Reward, Mogul, Reliance, Trojan, and Wasp No. 2 mills were also operated steadily. The small yield of placer gold came from Custer, Lawrence, and Pennington counties.

Silver.—The output of silver, derived mainly from refining the gold bullion produced, was 199,864 fine ounces, or about 23,000 ounces more than in 1914.

SOUTHERN APPALACHIAN STATES.

The total production of gold from 1799 to the end of 1915 in the southern Appalachian States, as shown from data compiled by the Bureau of the Mint and the United States Geological Survey, has been $50,913,818. The figures credit Alabama with $754,627, Georgia with $17,788,448, Maryland with $71,339, North Carolina with $23,588,358, South Carolina with $5,180,026, Tennessee with $237,079, and Virginia with $3,293,941.

Gold.—The combined mine production of gold in the southern Appalachian States in 1915 was $224,250, against $173,589 in 1914. North Carolina, with a yield of $172,001, had much the largest production; Georgia followed with $35,821; Tennessee with $6,862; Alabama with $5,243; South Carolina with $3,789; and Virginia with only $534. The gold produced in Tennessee was from copper ores of the Ducktown district. The gold production from 45 placer mines amounted to $24,050. Nearly all the remainder of the gold was from dry or siliceous ores.

[1] U. S. Geol. Survey Mineral Resources, 1915, pt. 1, p. 344, 1916.

Silver.—The mine production of silver from the southern Appalachian States was 102,166 ounces in 1915, against 100,727 ounces in 1914. About 1,600 ounces came from siliceous ores and placers and 100,543 ounces from the Ducktown copper ores of Tennessee.

TEXAS.

Gold.—The total output of gold from Texas mines from 1885 to the end of 1915 is given by Charles W. Henderson as $43,121.[1]

The gold yield has been very small and has been mainly a by-product. Some gold-silver bullion was made in Llano County in 1915, and the output of gold increased from $234 in 1914 to $1,503 in 1915.

Silver.—The total production of silver in Texas from 1885 to 1915, inclusive, has been 12,417,882 ounces, according to Henderson.[2] The mine production for 1915 was 675,473 fine ounces, against 530,817 ounces in 1914. The greater part of the silver continued to come from the Presidio silver mine and cyanidation mill in the Shafter district, Presidio County.

UTAH.

Gold.—The total output of gold in Utah from 1864 to 1915, inclusive, is given by V. C. Heikes, of the United States Geological Survey, as $86,189,230.[3] In 1915, the first time in several years, the output of gold showed an increase to $3,609,109 from $3,265,347 in 1914. The largest part of the gold was contained in ores produced in Salt Lake County and amounted to $2,516,844, an increase of more than $350,000. Juab County ranked next with $910,354, against $933,072 in 1914. The Bingham district, with its large output of copper and other ores, produced $2,507,477 in gold in 1915, and the Tintic district, partly in Juab County and partly in Utah County, produced $916,775 The placer gold production in 1915 was less than $1,000, and the output recovered by cyanidation and amalgamation was less than $30,000. The greater part of the Utah gold (58 per cent) was derived from copper ores mainly mined in Salt Lake and Juab counties; lead and lead-zinc ores contained 36 per cent.

Silver.—The total output of silver in Utah from 1864 to 1915, inclusive, has been 339,288,357 fine ounces, according to V. C. Heikes,[3] of the United States Geological Survey. The mine production of silver in Utah in 1915 was 12,313,205 ounces, an increase of 1,158,289 ounces. The largest production was from Juab County, credited with 4,005,600 ounces (mainly from lead ores), against 4,444,996 ounces in 1914. Salt Lake County had the next largest output, 3,152,267 ounces (from copper, lead, and lead-zinc ores), against 2,629,153 ounces in 1914. Of the Salt Lake County output of silver, the Bingham district produced 80 per cent. The Tintic district, in Juab and Utah counties, yielded 4,370,984 ounces (mainly from lead ores); and the Park City region, in Summit and Wasatch counties, produced 3,754,598 ounces, mainly derived from lead and lead-zinc ores. Altogether the lead ores of Utah yielded 7,759,842

[1] U. S. Geol. Survey Mineral Resources, 1915, pt. 1, p. 381, 1917.
[2] Idem.
[3] Heikes, V. C., Gold, silver, copper, lead, and zinc in Utah (mines report): U. S. Geol. Survey Mineral Resources, 1915, pt. 1, p. 385, 1916.

ounces of silver in 1915, the copper ores 2,065, 661 ounces, the lead-zinc ores 1,362,856 ounces and the dry or siliceous ores 1,035,712 ounces. The crude ore smelted in 1915 contained 9,778,223 ounces and concentrates contained 2,464,903 ounces.

WASHINGTON.

The total production of gold in Washington from earliest mining to the end of 1915 is given by C. N. Gerry, of the United States Geological Survey, as $26,378,713, and the total production of silver as 6,435,999 fine ounces.[1]

Gold.—The mine production of gold in Washington in 1915 was $391,419, against $557,173 in 1914. Of the production in 1915, more than 90 per cent was derived from ores shipped directly to smelters, 8 per cent came from ores treated by amalgamation or cyanidation, and nearly 2 per cent came from placers. Siliceous ores supplied about 96 per cent of all gold recovered and copper ores about 2 per cent. Ferry County alone produced $351,973 in 1915, against $513,276 in 1914. Nearly all the yield from Ferry County was, as usual, from the Republic district.

Silver.—The mine production of silver in Washington decreased from 264,861 ounces in 1914 to 255,837 ounces in 1915, of which Ferry County produced 103,472 ounces, mainly from siliceous ores, and Stevens County 109,750 ounces, mainly from copper ores.

WYOMING.

The total production of gold in Wyoming from 1867 to the end of 1915 is given by Charles W. Henderson as $1,210,776 and the output of silver for the same period as 59,636 ounces. [2]

The mine production of gold in Wyoming in 1915 was $14,592, against $5,006 in 1914, and that of silver 840 ounces in 1915, against 116 ounces in 1914. The Seminole and Elk Mountain districts, in Carbon County, yielded $12,810 in gold and 296 ounces of silver, mainly from siliceous ores treated by amalgamation.

PHILIPPINE ISLANDS.

The output of gold in the Philippines from 1907 to 1915, inclusive, has been $4,837,161. The mine production of gold for 1915 was $1,320,900, against $1,371,514 in 1914, $868,362 in 1913, and $570,212 in 1912. The mine production of silver in the Philippines in 1915 was 15,148 ounces and was recovered entirely from gold bullion refined.

NUMBER OF PRODUCING MINES.

The following table indicates the number of mines producing gold and silver in 1915 divided into placers and deep, or lode, mines. The placers are those in which the gold and the silver in natural alloy with the gold and, in a few instances, with platinum, are recovered from gravels and sands, whether by hand washing, sluicing, hydraulicking, drifting (in frozen ground or ancient buried river channels), or by dredging. The deep mines are those producing gold and silver

[1] U. S. Geol. Survey Mineral Resources, 1915, pt. 1, p. 561, 1916.
[2] Idem, p. 351.

(from ores as distinguished from gravels), mainly from underground workings, including those whose ores are valuable chiefly for copper, lead, or zinc, but which contribute precious metals as by-products. In addition to producing mines here enumerated, many properties were being prospected and developed without making any output in 1915, and many other mining claims were being held by assessment work only.

The enumeration of placer mines is less satisfactory than that of deep mines, because some of the operations are only temporary and individually small, and because the production is frequently by transitory miners not regularly working placer ground. The unit, so far as possible is, however, as for deep mines, not the operator, but the mining claim or group of claims.

Number of producing mines in 1915.[a]

State or Territory.	Number of mines.		
	Placer.	Deep.	Total.
Alabama	2	1	3
Alaska	700	41	741
Arizona	49	468	517
California	287	321	608
Colorado	35	786	821
Georgia	31	9	40
Idaho	186	226	412
Illinois[b]	.....	2	2
Maryland and Pennsylvania	.....	2	2
Michigan[b]	.....	11	11
Missouri[b]	.....	5	3
Montana	111	482	645
Nevada	103	696	799
New Mexico	26	148	174
North Carolina	22	7	29
Oregon	65	30	95
South Carolina	4	3	7
South Dakota	10	23	33
Tennessee[c]	.....	2	2
Texas	.....	12	12
Utah	5	229	234
Vermont and New Hampshire	.....	1	1
Virginia	.....	10	10
Washington	31	73	104
Wyoming	3	9	12
	1,720	3,597	5,317

[a] Philippines and Porto Rico not included.
[b] Number of mines contributing to silver production.
[c] Number of mines contributing to gold and silver production.

The table shows the number and distribution of mines producing gold and silver in the United States and Alaska. With the exception of (1) some of the Michigan copper mines, (2) all zinc mines in the Eastern and Central States, and a few in the Far West, and (3) all lead mines of the Central States (except a few in Illinois and southeastern Missouri), practically all mines producing copper, lead, and zinc in the United States and Alaska produce gold and silver also. The table, therefore, with these exceptions, is a table of mines producing these five metals. It also includes certain mines producing oxidized manganese iron fluxing ores of Colorado, Utah, and elsewhere, whose ores contain small quantities of precious metals, especially silver, and are smelted as flux.

Number of mines producing gold and silver, 1906–1915.

Year.	Placer.	Deep.	Total.	Year.	Placer.	Deep.	Total.
1906	2,316	2,114	4,430	1912	2,044	3,567	5,611
1907	2,586	2,604	5,190	1913	1,774	3,502	5,276
1908	2,599	2,864	5,463	1914	1,815	3,158	4,973
1909	2,187	3,183	5,370	1915	1,720	3,597	5,317
1910	2,026	3,299	5,325				
1911	2,146	3,553	5,699	Average	2,122	3,143	5,265

Comparison of the figures for 1915 shows a net total increase of 344 producing mines following decreases in 1912, 1913, and 1914. The total number of properties operated in 1915 was 52 in excess of the average for the last 10 years. The number of placer properties worked in 1915 showed a decrease of 95 and was nearly 600 less than the number operated in 1906. This is a natural result due to the exhaustion of the rich gravels and to the acquisition of large areas of placer ground by dredge mining companies. The number of deep mines operated increased from 3,158 in 1914 to 3,597 in 1915, or 454 more than the average for 10 years. High prices for copper, lead, and zinc in 1915 resulted in more deep mines being operated than in any year for which data are available by the Survey.

In total number of operating mines Colorado again ranked first with 821, followed in order by Nevada with 799, Alaska with 741, Montana with 643, California with 608, Arizona with 517, and Idaho with 412. In number of placers Alaska led with 700, followed by California with 287, and Idaho with 186; and in deep mines Colorado led with 786, followed by Nevada with 696, Montana with 482, Arizona with 468, and California with 321.

ORE PRODUCTION, CLASSIFICATION, AND AVERAGE VALUE.

The best index of deep mining is, of course, the quantity, metallic content, and value of ore mined, rather than the number of mines or of operators. In the next following table is given the production of ore by classes of ore and by States and Territories from mines producing gold and silver and the average extraction value of precious metals per ton.

The classification adopted is necessarily arbitrary in part. An ore is generally understood to be worked at a profit for one or more metals. The complex nature of western ores, especially, and the gradations from one well-recognized class to another render essential some fixed measures for the terminology used. The dry or siliceous ores comprise gold and silver ores proper, as well as fluxing ores carrying considerable quantities of iron and manganese oxides and very small quantities of gold and silver, and precious metal bearing ores carrying copper, lead, or zinc in quantities too low to classify them as copper, lead, zinc, or mixed ores. The distinction between gold and silver ores is not here made. The total number of silver mines and the total production of true silver ores are both very small. The copper ores include those containing over 2½ per cent of copper, or less than this percentage in the cases of the great disseminated copper deposits of the West and of the Lake Superior ores; in general, the lead ores are those containing 4½ per cent or more of lead, and the zinc ores are those containing 25 per cent or more of zinc, both irrespective of their precious metal content; but ores of lower grades in lead and

especially in zinc are treated profitably in some places, and of course they are then classified as lead or zinc ores, as the case may be. The mixed ores are combinations of those enumerated.

Ore produced and average extraction value of gold and silver per ton in 1915.[a]

State or Territory.	Dry or siliceous ores.		Copper ores.		Lead ores.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Alabama and Georgia	21,302	$1.26				
Alaska	3,020,607	2.02	369,609	$1.65		
Arizona	340,798	7.81	9,131,425	.42	48,536	$5.27
California	2,368,352	5.69	601,815	1.71	12,966	7.49
Colorado	2,183,431	10.80	23,573	9.84	142,969	7.18
Idaho	52,302	9.39	74,901	2.27	1,656,688	3.03
Maryland and Virginia[b]	51	9.17	72	.92		
Michigan[b]			2,000,000	.15		
Montana	493,500	8.17	4,863,378	1.05	13,783	20.71
Nevada	1,812,653	9.18	3,247,140	.44	15,508	11.08
New Mexico	163,241	10.99	2,552,609	.24	8,819	3.36
North Carolina[c]	25,910	6.35				
Oregon	151,076	9.44	3,722	1.80	993	3.44
South Carolina	2,424	1.56				
South Dakota	1,889,970	3.97			5	7.00
Tennessee[c]			623,534	.09		
Texas	54,376	6.22	311	6.19	281	12.94
Utah	61,976	11.56	9,436,450	.33	528,009	9.23
Washington	42,160	10.77	40,417	1.36	989	4.83
Wyoming	2,997	4.51	1,219	.66		
Total, 1915	12,687,126	6.26	32,973,166	.51	2,429,546	4.86
Percentage of tonnage	25.12		65.28		4.81	
Total, 1914	10,966,666	6.95	27,653,352	.49	2,307,550	5.29
Percentage of tonnage	25.46		64.26		5.36	

State or Territory.	Zinc ores.		Copper-lead and copper-lead-zinc ores.		Lead-zinc ores.		Total.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	
Alabama and Georgia							21,302
Alaska							3,390,207
Arizona	40,458	$2.20	426	$21.59	47,916	$2.77	9,612,559
California	19,646	3.09					3,002,779
Colorado	100,222	.13	2,674	34.81	284,151	1.20	2,737,020
Idaho	111,428	.63	2	7.50	513,525	1.59	2,408,816
Maryland and Virginia[b]							123
Michigan[b]							2,000,000
Montana	178,573	2.26	215	10.04	580,475	2.59	6,129,924
Nevada	24,816	1.31	1,563	13.23	16,910	2.55	5,118,620
New Mexico			742	10.01	71,661	.01	2,797,072
North Carolina[c]							25,910
Oregon							155,791
South Carolina							2,424
South Dakota							1,889,975
Tennessee[c]							623,534
Texas	60						55,028
Utah	31,320	.28	5,329	7.06	385,361	2.78	10,451,415
Washington	3,111						86,677
Wyoming							4,216
Total, 1915	512,634	1.32	10,951	15.55	1,900,029	2.06	50,513,452
Percentage of tonnage	1.01		.02		3.76		
Total, 1914	622,811	.19	11,577	12.87	1,488,747	2.90	43,050,703
Percentage of tonnage	1.44		.02		3.46		

[a] Illinois, Missouri, the Philippines, and Porto Rico not included; crude-ore tonnage, containing precious metals, not known.
[b] Includes only copper ore yielding precious metals.
[c] Lead and zinc ores yielded no precious metals.

The total quantity of ore sold or treated and from which gold or silver was produced increased from 43,050,703 short tons in 1914 to 50,513,452 short tons in 1915, which was the largest quantity of such ores ever recorded. The quantity of copper ores sold or treated increased more than 5,300,000 tons; that of dry or siliceous ores more than 1,720,000 tons; lead ores, 122,000 tons; and lead-zinc ores, 411,000 tons. Utah, Arizona, and Montana continued to lead in quantity of ore, owing to the largely increased output from copper mines, that from the first two States being mainly from low-grade disseminated ores and that from Montana mainly from the Butte vein deposits. Nevada ranked next in output of ore, mainly from Ely copper ores, but also from siliceous ores from Goldfield, Tonopah, and other districts. Alaska, California, New Mexico, and Colorado come next, with an output mainly of dry or siliceous ores from many districts in Alaska, California, and Colorado, and of copper ores from the low-grade ore bodies in New Mexico.

The large production of lead and lead-zinc ores in Idaho ranked that State before South Dakota, which yielded ores which were all dry or siliceous in character.

The average gold and silver extraction values were high for the siliceous ores of Colorado, New Mexico, Nevada, Montana, Oregon, Utah, Idaho, and Washington, and low for the larger ore bodies of California, South Dakota, and Alaska. Some of the States produced comparatively small quantities of copper ore carrying high extraction values in gold and silver, but the copper ores of the important copper-producing States showed low extraction values. The average recovery in gold and silver from the copper ores of Arizona was $0.42 a ton, that of Montana $1.05 a ton, that of Nevada $0.44, that of New Mexico $0.24, that of Utah $0.33, and that of Michigan $0.15. The lead ores of Utah showed an average recovery in gold and silver of $9.23 a ton, and the lead ores of Idaho only about one-third as much. Montana produced the largest quantity of gold and silver bearing lead ores, and also lead-zinc ores. Idaho yielded the next largest quantity of these classes of ore, but the gold and silver content of such ore was very much less than that of Montana ores of similar character. About 25 per cent of the output of ore considered as producing gold and silver was dry or siliceous ore, against 26 per cent in 1914; 65 per cent was copper ore, against 64 per cent in 1914; less than 5 per cent was lead ore; about 4 per cent was lead-zinc ore; and 1 per cent was zinc ore. The average precious-metal extraction value per ton of siliceous ores of the United States decreased from $6.95 to $6.26, that of lead ores from $5.29 to $4.86, and that of lead-zinc ores from $2.90 to $2.06. The average gold and silver value of copper ores per ton increased from $0.49 to $0.51, and that from zinc ores from $0.19 to $1.32.

DISTRIBUTION OF MINE PRODUCTION OF GOLD IN 1915, BY SOURCES.

As shown by the following table, the great bulk of the domestic output of gold is from dry or siliceous ores—normally gold quartz and gold-silver quartzose ores—and from placers, more than 90 per cent of the total production of gold coming from these sources alone. The total contribution of gold derived from the great copper, lead,

and zinc mines of the country is therefore relatively small, notwithstanding their recent enormous development and production.

It is interesting to note, however, that the placer mines and dry or siliceous ores yielded 2 per cent less of the total gold than they did in 1914 and that the output of gold from placer mines, which had advanced from nearly 24 per cent of the total gold in 1910 to more than 25 per cent in 1914, declined to about 23 per cent in 1915. This loss in percentage was due, however, not so much to decreased output from placers as to larger production from deep mines. The contribution of gold from dry or siliceous ores, which had gradually declined from about 69 per cent in 1910 to about 66 per cent in 1914, increased to nearly 68 per cent in 1915. The yield of gold from copper ores increased from 6 per cent in 1914 to 7 per cent in 1915.

Mine production of gold in 1915, in fine ounces.[a]

State or Territory.	Placers.	Dry or siliceous ores.	Copper ores.	Lead ores.	Zinc ores.	Copper-lead and copper-lead-zinc ores.	Lead-zinc ores.	Total.
Alabama	2.85	250.78						253.63
Alaska	506,970.00	293,588.99	7,407.23					807,966.22
Arizona	1,705.12	104,350.00	87,706.63	2,735.36	2,728.01	103.38	2,202.96	201,531.46
California	416,441.85	644,140.17	23,797.60	1,139.47	126.98			1,085,646.07
Colorado	33,538.86	1,012,897.34	6,204.17	26,068.24	28.01	2,098.50	3,487.79	1,084,322.91
Georgia	738.06	994.78						1,732.84
Idaho	28,294.05	21,935.45	3,997.33	2,306.28	8.27	.05	528.06	57,069.49
Montana	45,919.87	155,055.51	30,840.99	3,809.00	1,492.37	5.18	4,955.10	242,077.93
Nevada	19,123.55	466,358.56	63,043.85	2,463.69	558.01	134.72	.63	551,683.01
New Mexico	447.09	51,659.88	18,221.02	247.39		88.58	17.00	70,680.96
North Carolina	410.50	7,910.04						8,320.55
Oregon	23,324.97	66,573.39	83.01	83.01				90,064.38
South Carolina	11.99	171.30						183.29
South Dakota	76.72	358,203.14		.14				358,280.00
Tennessee			331.95					331.95
Texas		20.20		52.51				72.71
Utah	46.34	9,248.67	101,247.86	45,541.34	32.85	65.89	18,407.70	174,590.65
Virginia		22.64	3.19					25.83
Washington	346.36	18,277.72	308.59	2.23				18,934.90
Wyoming	34.06	639.23	32.60					705.89
Total, 1915	1,077,432.25	3,212,297.79	343,225.93	84,448.66	4,974.50	2,496.30	29,599.24	4,754,474.67
Value	$22,272,501	$66,404,089	$7,095,110	$1,745,709	$102,832	$51,603	$611,870	$98,283,714
Percentage of total	22.66	67.57	7.22	1.78	0.10	0.05	0.62	100
Total, 1914	1,117,930.90	2,940,872.77	264,831.79	74,514.32	1,913.15	547.77	17,451.08	4,418,061.78
Value	$23,109,683	$60,793,236	$5,474,559	$1,540,348	$39,548	$11,323	$360,746	$91,329,443
Percentage of total	25.30	66.56	6.00	1.69	0.04	0.01	0.40	

[a] Philippines and Porto Rico not included.

PLACERS.

GENERAL.

The total value of the production of gold from placers was $22,272,501 in 1915, against $23,109,683 in 1914. The placer production increased in Colorado and Nevada in 1915, but decreased in California, Alaska, Idaho, and Oregon.

The placer production is chiefly from dredging, from drift mining (which is of decreasing importance in Alaska in frozen ground at no great depth, but of continued importance in California in ancient buried river channels, often at considerable depth), and from hydraulic and sluicing placers. In California, especially, hydraulic

mining was of much importance in the past and had become a special branch of the industry in itself, but restrictive laws relative to the débris and to disturbance of navigable streams have in recent years greatly confined mining activity of this kind. Finally, there is a small annual output of gold from dry placers in the Southwest and also a production of gold and platinum from ocean-beach mining in California and Oregon.

Some interesting notes on beach mining in California and Oregon and on dry placers in California, by Charles G. Yale, and on dry placers in Arizona, Nevada, and New Mexico, by V. C. Heikes, were published in the Survey report on gold and silver for 1912, copies of which can still be had on application to the Director, United States Geological Survey, Washington, D. C.

A geologic investigation of the placer deposits of the United States is now being made by James M. Hill, of the United States Geological Survey, and cooperative work on the technology is being done by Charles Janin, of the United States Bureau of Mines. The investigation will require considerable field study as well as office work, and it is hoped that operators will assist in furnishing the necessary data requested, as well as the annual statistics for the Mineral Resources reports, in order that publication of the results may not be unduly delayed.

DREDGING.

The production of gold by dredging in the United States and Alaska from the commercial beginning of the industry in 1896 to the record output of 1915, inclusive, has amounted according to best available data, to $107,316,593, of which $79,111,231 came from California, $12,430,894 from Alaska, $7,457,161 from Montana, $3,408,384 from Colorado, and $3,394,360 from Idaho.

Brief details of dredging operations have been given in Mineral Resources in the mines reports on gold, silver, copper, lead, and zinc of the Western States and also in earlier reports of the Director of the Mint. A brief history of gold dredging in the United States was given in the gold and silver (general) report for the year 1914, and the gold production obtained by dredging in the United States and Alaska from 1896 to the end of 1914 and the number of dredges operated was given by States for each year. Further information is to be found in reports of geological surveys or mining officials of different States. A comprehensive and very useful report is contained in Bulletin 57 of the California State Mining Bureau, "Gold dredging in California," by W. B. Winston and Charles Janin. Another valuable treatise is "Dredging for gold in California," by D'Arcy Weatherbe, published by the Mining and Scientific Press; and additional information is constantly furnished by the technical press.

The gold recovered in the United States and Alaska by 114 gold dredges in 1915 was $12,483,125, against $12,512,783 by 120 dredges in 1914. Of the 1915 production California yielded $7,796,465 from 58 dredges, Alaska $2,330,000 from 35 dredges, Montana $861,626 from 5 dredges, Colorado $672,386 from 5 dredges, and Idaho $486,541 from 7 dredges. Two dredges operating in Baker County, Oreg., also had a large output.

Gold produced in the United States by dredges, 1896–1915.

Year.	Dredges.	California.	Alaska.	All other States.[a]	Total.
1896	2	$2,000	.....	$42,000	$44,000
1897	6	5,000	.....	113,556	118,556
1898	8	18,887	.....	168,813	187,700
1899	18	206,302	.....	227,876	434,178
1900	27	200,929	.....	319,108	520,037
1901	34	471,762	.....	268,251	740,013
1902	48	867,665	.....	501,857	1,369,522
1903	45	1,475,749	$20,000	420,315	1,916,064
1904	61	2,187,038	25,000	511,679	2,723,717
1905	68	3,276,141	40,000	371,235	3,687,376
1906	76	5,098,359	120,000	503,035	5,721,394
1907	79	5,065,437	250,000	340,265	5,655,702
1908	88	6,536,189	170,901	646,481	7,353,571
1909	96	7,382,950	424,993	975,656	8,783,599
1910	115	7,550,254	800,000	942,786	9,293,040
1911	119	7,666,461	1,500,000	1,159,908	10,326,369
1912	124	7,429,955	2,200,000	1,588,956	11,218,911
1913	116	8,090,294	2,200,000	1,936,642	12,226,936
1914	120	7,783,394	2,350,000	2,379,389	12,512,783
1915	114	7,796,465	2,330,000	2,356,660	12,483,125
	.....	79,111,231	12,430,894	15,774,468	107,316,593

[a] Other States that have produced gold by dredges are Colorado, which yielded, 1901–1915, $3,408,384; Idaho, 1897–1915, $3,304,360; Montana, 1896–1915, $7,457,161; and Oregon, New Mexico, Nevada, South Dakota, Wyoming, Alabama, Georgia, and North Carolina, with a combined yield, 1902–1915, of $1,514,563.

DRY AND SILICEOUS ORES.

In 1915 dry and siliceous ores, including true gold, gold-silver, and silver ores, and precious metal ores not classed primarily as copper, lead, zinc, or mixed ores, produced $66,404,089 in gold, against $60,793,236 in 1914, or more than 67.5 per cent of the total output in each year. The largest producers from this class of ore are in order of rank: Colorado, California, Nevada, South Dakota, and Alaska.

The siliceous ores are in part free-milling (amalgamating), as in Alaska, California, and Oregon; in part both amalgamating and concentrating, as in many States; in smaller part simply concentrating ores, as in parts of Colorado and Arizona; in increasing part all-sliming and cyaniding ores; and finally in some part smelting ores. Tailings both from old dumps and from present millings are largely reworked by concentration and subsequent cyanidation.

The loss in tailings from gold mills is being constantly cut down, and the most serious loss remains in tailings from concentrating plants. The chlorination process is of decreasing relative importance, having been used in only a few plants in California and Colorado in 1915. Smelting is mainly of concentrates and of siliceous and pyritic ores, which are also valuable as fluxes. Exact figures of relative output by methods will appear in detail by States in another table.

COPPER ORES.

The production of gold as a by-product of the smelting of copper ores sold or treated in 1915 was $7,095,110, against $5,474,559 in 1914, an increase from 6 per cent of the total gold yield in 1914 to 7.2 per cent in 1915. The largest production was in Utah, followed by Arizona, Nevada, and Montana, in the order given.

LEAD ORES.

The production of gold from refining lead bullion from lead ores sold or treated in 1915, chiefly from Utah and Colorado, was $1,745,709, against $1,540,348 in 1914, or 1.8 per cent of the total domestic output of gold in each year.

LEAD-ZINC, ZINC, AND OTHER ORES.

The production of gold from lead-zinc ores was $611,870 in 1915, against $360,746 in 1914; from zinc ores $102,832 in 1915, against $39,548 in 1914; and from copper-lead and copper-lead-zinc ores $51,603 in 1915, against $11,323 in 1914.

DISTRIBUTION OF MINE PRODUCTION OF SILVER IN 1915, BY SOURCES.

The mine production of silver from the three most important sources of silver—dry or siliceous ores, copper ores, and lead ores—was 89 per cent of the total output in both 1914 and 1915. The output from dry and siliceous ores decreased 4.5 per cent in 1915, that from lead ores decreased 0.3 per cent, and that from lead-zinc ores more than 1 per cent, but that from copper ores increased 4.6 per cent. The combined output from placers, zinc ores, copper-lead, and copper-lead-zinc ores, was a little more than 2 per cent of the total production of silver.

Mine production of silver in 1915, in fine ounces.[a]

State or Territory.	Placers.	Dry or siliceous ores.	Copper ores.	Lead ores.	Zinc ores.	Copper-lead and copper-lead-zinc ores.	Lead-zinc ores.	Total.
Alabama	2	10						12
Alaska	82,602	91,341	897,839					1,071,782
Arizona	303	994,184	4,010,510	333,444	64,547	13,923	172,103	5,649,020
California	37,868	324,277	1,056,895	145,034	114,682			1,678,756
Colorado	8,669	5,195,593	204,317	964,224	24,802	98,210	532,157	7,027,972
Georgia	39	99						138
Idaho	5,935	74,481	171,931	9,791,944	138,463	27	1,586,347	11,769,128
Illinois				3,864				3,864
Michigan			585,933					585,933
Missouri			16	57,740				57,756
Montana	7,775	1,635,221	8,819,772	407,859	734,798	4,045	2,768,967	14,378,437
Nevada	6,039	13,808,912	244,643	238,420	41,295	35,301	85,239	14,459,840
New Mexico	55	1,431,350	513,288	48,371		11,044	1,423	2,005,531
North Carolina	51	1,414						1,465
Oregon	5,527	99,264	9,807	3,349				117,947
South Carolina		8						8
South Dakota	6	199,795		63				199,864
Tennessee			100,543					100,543
Texas		666,641	3,797	5,035				675,473
Utah	4	1,035,712	2,065,661	7,759,842	17,633	71,497	1,362,856	12,313,205
Vermont and New Hampshire			379					379
Washington	94	150,633	95,766	9,344				255,837
Wyoming	2	570	268					840
Total, 1915	154,968	25,709,505	18,781,365	19,828,533	1,136,220	234,047	6,509,092	72,353,730
Value	$78,569	$13,034,719	$9,522,152	$10,053,066	$576,063	$118,662	$3,300,109	$36,683,340
Percentage of total	0.21	35.53	25.96	27.40	1.57	0.33	9.00	1.00
Total, 1914	152,128	27,812,335	14,829,828	19,302,081	145,264	248,866	7,132,747	69,623,249
Value	$84,126	$15,380,221	$8,200,895	$10,674,051	$80,331	$137,623	$3,944,409	$38,501,656
Percentage of total	0.22	39.95	21.30	27.72	0.21	0.36	10.24	

[a] Philippines and Porto Rico not included in this table.

PLACERS.

The output of silver from the refining of placer gold was 154,968 fine ounces in 1915, against 152,128 ounces in 1914. Seventy-eight per cent of the production was from Alaska and California.

DRY AND SILICEOUS ORES.

The mine production of silver from dry and siliceous ores in 1915 was 25,709,505 fine ounces, against 27,812,235 ounces in 1914. About 54 per cent of this was from Nevada (chiefly from the Tonopah district) and 20 per cent was from Colorado (mainly from the Leadville, Upper San Miguel, and Sneffels districts). New Mexico, Montana, and Utah also each produced more than 1,000,000 ounces of silver from this source. Texas was one of the largest producers of silver from siliceous silver ores.

A large part of the silver from gold-silver siliceous ores is obtained with the gold by amalgamation and cyanidation in the mills, and the silver is recovered by refining the mill bullion. The remainder is produced by smelting the richer ores and refining the copper or lead bullion produced.

COPPER ORES.

The mine production of silver from domestic copper ores in 1915 was 18,781,365 fine ounces, against 14,829,828 ounces in 1914. The increased production of silver from copper ores mined in Alaska, Arizona, Utah, Montana, and New Mexico amounted to 4,375,154 ounces.

The production of silver from copper ores is from the electrolytic refining of Lake and blister copper produced by smelting. The copper ores are mainly sulphides (except the Lake ores of Michigan, which are native metal in amygdaloid and conglomerate matrix), and a greater tonnage contains chalcocite than chalcopyrite or cupriferous pyrite. The great disseminated copper deposits of Utah, Arizona, Nevada, and New Mexico are of increasing importance, and the lode deposits of Butte, Mont., have long been famous. The silver tenor of the extensive Chino disseminated deposits of the Santa Rita district, N. Mex., is notably low, but similar deposits elsewhere add large quantities of silver.

Deducting the copper ore from Michigan and the silver recovered in refining the metal derived therefrom it is shown that 30,973,166 tons of copper ore yielded 18,195,432 ounces of silver, or slightly less than 0.6 ounce per ton.

In output of silver from copper ores Montana continued to lead with 8,819,772 ounces in 1915, against 8,015,694 ounces in 1914; Arizona followed with 4,010,510 ounces in 1915, against 2,604,371 ounces in 1914; Utah ranked third with 2,065,661 ounces in 1915, against 1,726,230 ounces in 1914; and California produced 1,056,895 ounces in 1915, against 703,042 ounces in 1914. The production of Montana is mainly from Butte, that of Arizona has been chiefly from Bisbee and Jerome, that of Utah from Tintic and Bingham, and that of California from Shasta County. Of these districts Bisbee well represents the

disseminated type; Bingham produces from both lode and disseminated deposits; and the remainder produce silver chiefly from copper ore mined from deep lodes.

LEAD ORES.

The mine production of silver from argentiferous lead ores in 1915 was 19,828,533 fine ounces, against 19,302,081 ounces in 1914, a considerable increase in 1915 over 1914 and a notable increase over 1913 and 1912. The output from Idaho increased from 8,697,580 ounces in 1914 to 9,791,944 ounces in 1915, that of Utah increased from 7,350,213 ounces to 7,759,842 ounces, but that of Colorado decreased from 1,532,943 ounces to 964,224 ounces. The yield in Idaho is mainly from the silver-lead ores of the Coeur d'Alene, that in Utah is chiefly from the Park City and Tintic districts, and that in Colorado from Aspen and Leadville. Most of the output is from the desilverization of lead bullion from smelting of western ores and concentrates.

ZINC, LEAD-ZINC, AND MIXED ORES.

Argentiferous zinc ores produced 1,136,220 ounces of silver in 1915, against 145,264 ounces in 1914, mainly as refinery by-products from the smelting of zinc concentrates from Montana, Idaho, California, and Arizona. The production from Montana zinc ores increased from 48,373 ounces in 1914 to 734,798 ounces in 1915, that from California zinc ores increased 114,682 ounces, and that from Idaho zinc ores increased 133,424 ounces.

Lead-zinc ores produced 6,509,092 fine ounces of silver in 1915, against 7,132,747 ounces in 1914, chiefly from concentrates from the Coeur d'Alene in Idaho, the Butte district in Montana, and the Park City region in Utah. The putput from both Utah and Montana greatly increased in 1915.

Copper-lead and copper-lead-zinc ores produced 234,047 ounces of silver in 1915, against 248,866 ounces in 1914. The output was mainly from Colorado, Utah, and Nevada.

DISTRIBUTION OF PRODUCTION OF GOLD AND SILVER BY METHODS OF TREATMENT.

In the following table is given a summary of the distribution of the production of gold and silver in the United States in 1915, showing (1) total crude ore, tailings, and slags sold or treated; (2) crude ore treated in gold and silver mills; (3) crude ore concentrated, with resulting concentrates; (4) crude ore shipped to smelters; (5) old tailings and slags treated. The last four items include recoverable gold and silver content in fine ounces.

Distribution of gold and silver produced in 1915, by States.[a]

State or Territory.	Total quantity of ore, tailings, and slag treated or sold in 1915.	Ore to gold and silver mills.			Ore to concentrating mills.	Concentrates produced.		
		Quantity.	Gold in bullion.	Silver in bullion.	Quantity.	Quantity.	Gold.	Silver.
	Short tons.	*Short tons.*	*Fine ounces.*	*Fine ounces.*	*Short tons.*	*Short tons.*	*Fine ounces.*	*Fine ounces.*
Alaska	3,390,207	3,020.573	181,291	29,733	229,035	68,889	112,233	349,591
Arizona	9,612,559	301,276	92,965	741,578	6,606,759	521,676	18,585	910,138
California	3,002,779	2.286,569	494,766	171,943	.....	44,444	115,845	23,140
Colorado	2,737,020	1.611,335	662,305	608,072	557,267	233,965	128,015	2,214,689
Idaho	2,408,816	51,099	19,688	33,572	2,184,485	336,616	2,721	8,571,521
Montana	6,129.924	343,544	57,611	313,784	4,987,016	1,689,425	33,264	9,991,826
Nevada	5,118,620	1,620,289	440,285	12,504,864	3,199,413	458,162	40,089	859,587
New Mexico	2,797,072	149,650	40,474	1,129,701	2,428,344	174,074	12,877	323,402
Oregon	155,791	130,863	61,481	95,990	.....	953	3,592	1,351
South Dakota	1,883,975	1,888,598	356,217	196,360	.....	.....	.....	.....
Texas	55,028	54,293	20	665,804	.....	.....	.....	.....
Utah	10,451,445	2,167	1,389	6,491	9,370,438	596,363	59,019	2,464,903
Washington	86,677	3,032	1,453	4,463	35,210	2,584	31	67,706
Wyoming	4,216	2,900	620	296	.....	.....	.....	.....
Eastern or Appalachian States	674,821	42,765	6,025	1,147	4,303	260	2,236	275
Total	48,514,980	11,508,953	2,416,590	16,503,801	29,602,270	4,127,411	528,507	25,778,129
Total, 1914	40,679,262	9,761,336	2,224,518	15,656,831	24,306,504	3,613,024	466,620	24,102,264

State or Territory.	Crude ore to smelters.			Old tailings and slag treated.		
	Quantity.	Gold.	Silver.	Quantity.	Gold.	Silver.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Short tons.*	*Fine ounces.*	*Fine ounces.*
Alaska	140,599	7,472	609,856	.....	.....	.....
Arizona	2,614,897	88,099	3,945,730	89,627	[b]177	[b]51,265
California	706,402	57,418	1,445,037	9,808	1,175	768
Colorado	568,418	260,464	4,196,542	.....	.....	.....
Idaho	169,402	6,366	3,158,100	3,860	(c)	(c)
Montana	724,759	105,155	4,031,254	74,605	[d]128	[d]33,798
Nevada	233,408	51,837	1,045,153	65,510	[e]348	[e]44,206
New Mexico	219,078	16,883	552,373	.....	.....	.....
Oregon	4,781	415	13,872	20,147	1,251	1,207
South Dakota	1,377	1,986	3,198	.....	.....	.....
Texas	735	53	9,669	.....	.....	.....
Utah	958,067	113,554	9,778,223	120,773	[f]582	[f]63,581
Washington	48,435	17,105	183,574	.....	.....	.....
Wyoming	1,316	52	542	.....	.....	.....
Eastern or Appalachian States	626,705	1,273	101,005	1,048	153	76
Total	7,018,379	728,132	29,074,428	385,378	3,814	194,901
Total, 1914	6,292,218	604,113	28,841,241	319,204	4,880	394,005

[a] Exclusive of small quantity of silver from copper ores in Michigan and Missouri, and from lead ores in Illinois and Missouri, and of gold and silver from the Philippine Islands and Porto Rico.
[b] Gold and silver from 723 tons of old tailings included under recoveries from gold and silver mills.
[c] Included under recoveries from gold and silver mills.
[d] Gold and silver from 15,100 tons of old tailings included under recoveries from gold and silver mills.
[e] Gold and silver from 71,338 tons of old tailings included under recoveries from gold and silver mills.
[f] Gold and silver from 11,296 tons of old tailings included under recoveries from gold and silver mills.

The first item consists of all classes of ores, tailings, and slags from which gold and silver was produced in 1915. The grand total is 48,514,980 short tons in 1915, against 40,679,262 tons in 1914. This takes no account of placer gravel but represents output of mines producing ore only. The greatest output was from Utah, Arizona, Montana, and Nevada, all notable for large yield of copper ores.

In reference to the second item many gold and silver mills employ concentrating apparatus, and the concentrates obtained are combined in the table with those from straight concentrating mills under the heading "concentrates produced." The gold and silver recovery under this item is mainly by amalgamation and cyanidation, as is shown in detail in the last table of this report. The total quantity of crude ore treated in gold and silver mills in 1915 was 11,508,953 short tons, against 9,761,336 tons in 1914, and was the largest quantity so treated since these figures were first compiled by the Survey for 1910. The greatest quantities milled were in Alaska, California, South Dakota, Colorado, and Nevada. The total recovery of gold from the mills was 2,416,590 fine ounces in 1915, against 2,224,518 ounces in 1914, and the production was, as usual, chiefly from Colorado, California, Nevada, and South Dakota, in the order named. The total silver recovery in mills was 16,503,801 fine ounces, against 15,656,831 ounces in 1914, and came very largely from Nevada (from Tonopah and Goldfield chiefly), but also in considerable part from New Mexico, Arizona, Texas, and Colorado.

Under the third item is given the quantity of ore treated by concentration only, including the large quantities of copper, lead, zinc, and mixed ores, whose concentrates are smelted primarily for these metals, the gold and silver being recovered in refining the copper and lead bullion and smelting the zinc residues. Examples are the copper ores of the disseminated deposits of Bingham, Utah, and of New Mexico and Nevada; the copper ores of Butte, Mont.; the lead and lead-zinc ores of Cœur d'Alene, Idaho; Butte, Mont., and Leadville, Colo. The quantity of concentrates produced and the recoverable gold and silver content, however, as already stated, represent not only the concentrates from these straight concentrating mills but also those from gold and silver mills. These concentrates are mainly smelted but are also treated in gold and silver mills by the processes named. The ore treated in straight concentration mills increased from 24,306,504 short tons in 1914 to 29,602,270 tons in 1915, mainly because of the much greater activity at copper mines. Utah ranked first in quantity of ore concentrated, followed by Arizona, Montana, Nevada, New Mexico, and Idaho. These quantities, with the exception of those of Montana and Idaho, represent largely low-grade disseminated copper ores milled. The total quantity of gold and silver-bearing concentrates from all classes of milling ore increased from 3,613,024 short tons in 1914 to 4,127,411 tons in 1915. Montana mills produced the largest quantity of concentrates, followed by those of Utah, Arizona, Nevada, and Idaho. The total recoverable gold content of all concentrates was 528,507 ounces in 1915, against 466,620 ounces in 1914, and came mainly from Colorado, California, Alaska, Utah, and Nevada, in the order named. The total recoverable silver from concentrates produced was 25,778,129 fine ounces in 1915, against 24,102,264 ounces in 1914, and came chiefly from Montana, Idaho, Utah, Colorado, and Arizona.

The fourth item covers the quantity and the recoverable precious-metal content of crude ores shipped from the mines direct to the smelters, and in general includes the richer gold, silver, copper, lead, and mixed ore from which the gold and silver is eventually recovered by refining the copper or lead bullion that collects the precious metals in the smelting. The total quantity shipped of this class of ore in-

creased from 6,292,218 short tons in 1914 to 7,018,379 tons in 1915. The output was notably from Arizona, followed by Utah, Montana, California, Eastern or Appalachian States, and Colorado, in the order named. The total yield of gold from crude ores smelted increased from 604,113 fine ounces in 1914 to 728,132 ounces in 1915 and came chiefly from Colorado, Utah, Montana, Arizona, California, and Nevada, in the order given. The total recoverable silver output increased from 28,841,241 fine ounces in 1914 to 29,074,428 ounces in 1915 and was notably from Utah, Colorado, Montana, Arizona, and Idaho.

Under the fifth item is given the quantity of old materials, principally tailings and slags, re-treated, and their recoverable contents. These are partly smelted, often for their fluxing as well as their metal value; but considerable quantities of old tailings are now concentrated and cyanided, and impounding of mill tailings for future treatment as well as because of legal requirements has now become a general practice. The total quantity of all old material treated as shown in the table increased from 319,204 short tons in 1914 to 385,378 tons in 1915. Part of the gold and silver derived from old tailings is included under recoveries by amalgamation and cyanidation at gold and silver mills.

From this table the output of ore from the Central States, producing small quantities of silver and no gold, has been omitted. The output of zinc ore from the Eastern States is also omitted, as this zinc ore is reported to produce neither silver nor gold.

Percentage of output of gold and silver produced by different processes, 1912–1915.

Process.	Percentage of total output.							
	Gold.				Silver.			
	1912	1913	1914	1915	1912	1913	1914	1915
Placers	24.8	24.9	25.2	22.7	0.2	0.2	0.2	0.2
Gold and silver mills:								
By amalgamation	22.3	21.5	20.9	22.8	1.2	.6	.4	.4
By cyanidation	30.9	31.2	31.4	30.4	17.8	19.7	22.1	22.1
By chlorination	.4	.3	.4	.5	.....	.....	.....	.....
Total milling	53.6	53.0	52.5	53.7	19.0	20.3	22.5	22.5
Smelting [a]	21.6	22.1	22.1	23.6	80.8	79.5	77.3	77.3
Total [b]	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0

[a] Both crude ore and concentrates. [b] Philippine Islands and Porto Rico excluded.

The placers produced about 23 per cent of the total output of gold, a considerable decrease. The dredges produced nearly as much gold in 1915 as in 1914, but the combined placer yield from hydraulic, drift, and other surface methods was smaller. The percentage of output of silver credited to the placers is insignificant. In the mills the amalgamation process showed a gain of nearly 2 per cent of the total gold recovery in 1915. This was due to the more extensive mining and milling in California, South Dakota, Nevada, Alaska, and Colorado, which States produce ores more amenable to treatment by amalgamation.

The gold recovered by cyanidation showed a slight decrease, which possibly may have been due to the much increased cost of cyanides

and of zinc dust and shavings. The chlorination process was only used in a few mills in California and Colorado, and the output of gold showed little variation in 1914 and 1915.

Experiments were made in the treatment of sulphide ores carrying gold and silver by means of the flotation process. A large quantity of these ores are now cyanided direct, and the successful application of the flotation process will result in decreased yield of gold and silver from cyanidation. It is probable, however, that this decrease, if any, will be small, for at least part of the flotation concentrates will be cyanided and not shipped to smelters. This method is said to have been adopted by the Goldfield Consolidated Mines Co., which has retained part of the cyanide plant for treatment of tailings and the flotation concentrates.

The smelters have been producing each year a slightly greater proportion of gold and a smaller proportion of silver, and are to be credited in 1915 with about 24 per cent of the total output of gold and 77 per cent of the silver.

The bulk of the output of silver, however, is still from the smelting of crude ore, concentrates, and other material, but in decreasing ratio as the ratio of output from cyanidation increases. The bulk of the gold output remains also mainly from the gold mills, but in decreasing proportion, for although the output from cyanidation increases it does not offset the decrease by amalgamation and chlorination and the increase from the smelting of crude ores and concentrates.

The following table shows in greater detail the ore treated and the output of gold and silver mills, by States, in 1915:

Gold and silver produced at mills in 1915.[a]

State.	Ore and tailings treated.	Bullion recovered.				Percentage of gold and silver from all sources.			
		Amalgamation.		Cyanidation.		Amalgamation.		Cyanidation.	
		Gold.	Silver.	Gold.	Silver.	Gold.	Silver.	Gold.	Silver.
	Short tons.	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*	*Fine ounces.*				
Alaska	3,020,607	212,801	81,934	80,788	9,407	26.3	7.7	10.0	0.9
Arizona	301,999	6,885	1,797	86,080	739,781	3.4	.....	42.7	13.1
California[b]	2,296,377	419,269	101,036	76,672	71,675	38.6	6.0	7.1	4.2
Colorado[b]	[c]1,862,221	80,417	37,422	578,685	570,648	7.4	.5	53.4	8.1
Idaho	51,099	17,970	20,212	1,718	13,360	31.5	.2	3.0	.1
Montana	358,644	5,199	2,020	52,412	311,764	.2	.....	21.7	2.2
Nevada	1,681,627	70,243	46,103	370,042	12,458,761	12.7	.3	70.7	86.2
New Mexico	149,650	16,392	2,956	24,082	1,126,746	23.2	.1	34.1	56.2
Oregon	151,012	18,873	23,375	43,859	73,822	20.9	19.8	48.7	62.6
South Dakota	1,888,598	228,315	63,554	127,902	132,806	63.7	31.8	35.7	66.4
Texas	54,293	20	14	.....	665,790	27.8	.....	.....	98.5
Utah	13,463	946	496	443	5,998	.5	.....	.3	.....
Washington	3,032	777	119	676	4,344	4.1	.....	3.6	.2
Wyoming	2,900	620	296	.....	.....	87.8	35.3	.....	.....
Appalachian States	42,765	5,307	1,125	718	22	48.9	1.1	6.6	.....
Total, 1915	11,878,287	1,084,034	382,459	1,444,077	16,184,924	22.8	.4	30.4	22.1
Value[d]	.....	$22,408,971	$193,907	$29,851,721	$8,205,756	.....	.....	.....	.....
Total, 1914	[c]9,849,085	924,253	271,417	1,384,935	15,399,836	20.9	.4	31.4	22.1
Value[c]	.....	$19,106,005	$150,093	$28,629,147	$8,516,110	.....	.....	.....	.....

[a] Porto Rico and Philippine Islands excluded.
[b] Recovered by chlorination, 21,878.08 ounces of gold in California and 3,202.89 ounces in Colorado; and silver recovered by chlorination, 3,747 ounces in California and 2 ounces in Colorado.
[c] Represents crude ore and tailings, some of which were treated by amalgamation followed by cyanidation.
[d] Value of gold recovered by chlorination, $518,468; value of silver, $1,901.

Figures corresponding to those in this table were collected and compiled for the entire United States by the Survey for the first time in 1911, and comparison for five years can therefore now be made.

The total quantity of crude ore treated and old tailings re-treated in gold and silver mills was 11,878,287 short tons in 1915, against 9,849,085 tons in 1914, 9,401,856 tons in 1913, 9,677,360 tons in 1912, and 9,670,483 tons in 1911.

The great bulk of the ore treated, as shown, was milled in South Dakota, California, Alaska, Colorado, and Nevada, in the order named, and here the famous mills of the Homestake, Mother Lode, and Grass Valley, Treadwell, Cripple Creek, Tonopah, and Goldfield mines are especially in evidence. Large numbers of smaller mills, however, mark the wide distribution of gold mining in these regions and in many other scattered districts.

The total yield of gold by amalgamation in the United States in 1915 was 1,084,034 fine ounces, valued at $22,408,971, against 924,253 ounces, valued at $19,106,005 in 1914. The output in 1915 was 419,269 ounces in California, 228,315 ounces in South Dakota, 212,801 ounces in Alaska, 80,417 ounces in Colorado, and 70,243 ounces in Nevada. California showed the largest increase (65,883 ounces) in gold recovered by amalgamation.

The total yield of silver by amalgamation in 1915 was only 382,459 fine ounces, valued at $193,907, against 271,417 ounces, valued at $150,093, in 1914. The output was mainly from California, Alaska, South Dakota, Nevada, and Colorado, in the order given, and was chiefly of silver alloyed with gold.

The total output of gold by cyanidation in 1915 was 1,444,077 fine ounces, valued at $29,851,721, against 1,384,935 ounces, valued at $28,629,147, in 1914. The output was 578,685 ounces in Colorado, 370,042 ounces in Nevada, 127,902 ounces in South Dakota, 86,080 ounces in Arizona, 80,788 ounces in Alaska, and 76,672 ounces in California in 1915.

The total silver yield by cyanidation in 1915 was 16,184,924 fine ounces, valued at $8,205,756, against 15,399,836 ounces, valued at $8,516,110, in 1914. Nevada led, with the bulk of the output—12,458,761 ounces—and was followed by New Mexico with 1,126,746 ounces, Arizona with 739,781 ounces, Texas with 665,790 ounces, and Colorado with 570,648 ounces. The most notable gains were in Arizona, 123,746 ounces; Texas, 123,746 ounces; and Nevada, 396,981 ounces.

Of the gold-producing States, whose chief output is from milling ores, Alaska, California, and South Dakota still yield more gold by amalgamation than by cyanidation, whereas the latter process produces more gold than amalgamation in Colorado, Arizona, and Nevada; and it produces much more silver in Arizona, Colorado, Montana, Nevada, New Mexico, South Dakota, and Texas. Altogether amalgamation produced gold and silver valued at $23,602,878 from milling ores in 1915, against $38,057,477 produced by cyanidation from such ores in that year.

Of the total output of gold from all sources in 1915, amalgamation produced 26.3 per cent in Alaska, 38.6 per cent in California, and 63.7

per cent in South Dakota, and cyanidation produced 42.7 per cent in Arizona, 53.4 per cent in Colorado, 70.7 per cent in Nevada, 34.1 per cent in New Mexico, and 35.7 per cent in South Dakota.

Of the total output of silver from all sources in 1915 amalgamation produced 31.8 per cent in South Dakota and 19.8 per cent in Oregon, and cyanidation produced 86.2 per cent in Nevada, 56.2 per cent in New Mexico, 66.4 per cent in South Dakota, and 98.5 per cent in Texas.

For details of the consumption of quicksilver in the amalgamation milling process and of potassium cyanide and sodium cyanide in the cyanidation process the reader is referred to the mines reports of the several Western States indicated in the prefatory note. Data as to consumption of these supplies are not yet furnished by a sufficient number of mining and milling companies to justify tabulation for the entire United States. It has been estimated by H. D. McCaskey that the annual consumption of quicksilver in the amalgamation process in the United States (including Alaska) for the period 1911 to 1915, inclusive, has varied between 90,000 and 100,000 pounds.

Potassium and sodium cyanides consumed in certain Western States, 1913–1915, in pounds.

	Potassium cyanide.			Sodium cyanide.		
	1913	1914	1915	1913	1914	1915
Arizona			715			226,427
Colorado	659,374	35,800	39,600	260,589	935,589	1,088,592
Idaho			2,894			3,725
Montana			1,003			162,377
Nevada			13,514			3,050,092
New Mexico	1,415		29,000	190,190	237,511	216,709
South Dakota	113,727	89,649	11,477	388,961	425,397	458,300
Utah			36			5,320
Washington			1,200			3,400
	774,516	125,449	99,439	839,740	1,598,497	5,214,942

In the following tables compiled by V. C. Heikes, of the United States Geological Survey, some details are given for the consumption of quicksilver and of the cyanide in the recovery of gold and silver in six Western States from 1911 to 1915, inclusive.

Quicksilver consumed in certain Western States, 1911–1915.

State and year.	Number of mills using quicksilver.	Ore and tailings treated.	Total quicksilver.[a]	Quicksilver consumed (average per ounce of gold and silver bullion).
Arizona:		*Short tons.*	*Pounds.*	*Pounds.*
1911	26	46,833	1,362.00	0.086
1912	40	28,028	1,414.30	.098
1913	18	36,338	2,912.68	.158
1914	22	44,808	1,802.00	.116
1915	32	34,360	547.00	.063
Idaho:				
1911	35	72,210	1,648.00	.057
1912	43	34,609	700.00	.020
1913	40	28,258	254.00	.019
1914	29	25,877	598.00	.042
1915	36	46,423	1,040.00	.027
Montana:				
1911	24	61,767	898.00	.031
1912	17	48,837	783.59	.047
1913	23	14,508	289.57	.077
1914	18	29,983	408.00	.074
1915	24	28,504	371.00	.051
Nevada:				
1911	56	781,463	4,753.00	.012
1912	49	388,714	6,636.73	.044
1913	39	360,579	5,054.73	.051
1914	42	250,408	6,826.00	.063
1915	47	211,729	4,367.00	.038
Utah:				
1911	6	5,020	105.00	.058
1912	4	558	27.70	.145
1913	3	1,157	71.81	.107
1914	2	553	20.00	.108
1915	3	1,399	30.00	.020
Washington:				
1911	5	11,846	526.00	.197
1912	9	4,609	121.00	.043
1913	9	768	43.82	.038
1914	5	2,146	43.00	.039
1915	3	1,286	28.00	.031

State.	1911	1912	1913	1914	1915
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Arizona	1,362.00	1,414.30	2,912.68	1,802.00	547.00
Idaho	1,648.00	700.00	254.00	598.00	1,040.00
Montana	898.00	783.59	289.57	408.00	371.00
Nevada	4,753.00	6,636.73	5,054.73	6,826.00	4,367.00
Utah	105.00	27.70	71.81	20.00	30.00
Washington	526.00	121.00	43.82	43.00	28.00
	9,292.00	9,683.32	8,626.61	9,697.00	6,383.00

[a] Partly estimated.

Potassium and sodium cyanides consumed in certain Western States, 1911–1915.

State and year.	Number of mills using cyanidation process.	Ore and tailing treated.	Total consumption of cyanide.[a]	Cyanide consumed.	
				Average per ton of ore and tailing.	Average per ounce of gold and silver.
Arizona:		*Tons.*	*Pounds.*	*Pounds.*	*Pounds.*
1911	9	152,815	115,877	0.758	0.919
1912	9	202,285	129,987	.642	.973
1913	11	208,591	189,291	.907	1.138
1914	13	294,827	264,969	.900	.369
1915	17	267,639	227,142	.850	.275
Idaho:					
1911	10	64,510	181,808	2.818	4.300
1912	5	54,477	161,156	2.958	3.360
1913	6	37,303	94,475	2.533	3.400
1914	10	12,094	32,529	1.800	2.530
1915	10	4,676	6,619	1.410	.440
Montana:					
1911	27	203,912	91,657	.449	.610
1912	21	184,487	93,344	.506	.913
1913	24	170,348	116,422	.683	.958
1914	13	192,235	151,738	.789	.921
1915	18	330,140	163,380	.494	.449
Nevada:					
1911	41	1,083,883	2,352,961	2.170	.313
1912	37	1,179,365	2,618,424	2.220	.252
1913	29	1,326,793	2,798,224	2.109	.228
1914	36	1,240,337	3,217,886	2,365	.258
1915	37	1,479,898	3,063,606	2.070	.239
Utah:					
1911	6	268,691	205,041	.763	1.450
1912	6	170,809	203,721	1.193	2.380
1913	6	81,940	70,238	.857	.956
1914	4	17,113	7,396	.432	.607
1915	3	12,064	5,356	.440	.830
Washington:					
1911	3	17,381	9,700	.544	2.605
1912	4	16,703	36,517	2.186	.993
1913	2	20,410	32,090	1.572	.993
1914	2	22,387	48,820	2.180	.999
1915	4	1,746	4,600	2.600	.916

State.	1911	1912	1913	1914	1915
	Pounds.	*Pounds.*	*Pounds.*	*Pounds.*	*Pounds.*
Arizona	115,877	129,987	189,291	264,969	227,142
Idaho	181,808	161,156	94,475	32,529	6,619
Montana	91,657	93,344	116,422	151,738	163,380
Nevada	2,352,961	2,618,424	2,798,224	3,217,886	3,063,606
Utah	205,041	203,721	70,238	7,396	5,356
Washington	9,700	36,517	32,090	48,820	4,600
	2,957,044	3,243,149	3,300,740	3,723,338	3,470,703

[a] Partly estimated.

It has not been possible to obtain a complete report showing the total consumption of potassium cyanide and sodium cyanide used in the recovery of gold and silver in the United States in 1915. If the quantity used in California, Alaska, Texas, and Oregon be added to the 5,314,381 pounds reported to have been used in other Western States the estimated total consumption was probably about 3,000 tons.

The figures given indicate the increasing trend toward the elimination of potassium cyanide in the recovery of gold and silver. The growing scarcity of potassium cyanide necessarily increased the use

of sodium cyanide which is much cheaper. However, the cost of sodium cyanide is now greater than under normal trade conditions, and the domestic supply has not been sufficient to supply the domestic consumption. The quantity of cyanide used per ton of ore or tailings treated and the quantity of gold and silver recovered per pound of cyanide show considerable variations. These variations are doubtless due in part to greater efficiency in large milling plants in some of the States but are mainly caused by the difference in the character and varying metal content of the ores treated.

COBALT.

By Frank L. Hess.

PRODUCTION.

No cobalt or cobalt minerals are known to have been produced in the United States in 1915, but a certain quantity of cobalt was used by manufacturers of tool steel and in the making of stellite, all of which is thought to have been imported, although no imports of the metal are recorded separately.[1] The price of the metal during the year seemed to range between $1.25 and $2 a pound.

IMPORTS.

The following table is made up from statistics compiled by the Bureau of Foreign and Domestic Commerce:

Cobalt oxide, cobalt ore, and zaffer imported for consumption in the United States, 1906–1915.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1906	41,084	$83,167	1911	602,454	$59,151
1907	48,013	74,849	1912	791,242	83,080
1908	219,098	17,677	1913	209,396	95,735
1909	12,132	11,096	1914	334,556	274,538
1910	14,935	6,352	1915	208,047	219,111

TESTS.

The commonest cobalt minerals—linnæite (Co_3S_4), generally containing also some nickel and iron; smaltite ($CoAs_2$); cobaltite (CoAsS); and erythrite ($Co_3(AsO_4).8H_2O$)—may be easily tested by heating a fragment of the mineral in a bead of borax or of a salt of phosphorus before the blowpipe. A very small quantity of cobalt will give a beautiful blue color to either bead, even in the presence of considerable quantities of copper, iron, and nickel. If copper and nickel interfere the bead may be heated on charcoal in the reducing flame with a granule of tin, thus reducing the nickel and copper to the metallic state, after which the flux will show the blue cobalt color. Iron, when in quantity sufficient to interfere, must be removed by solution and precipitation.

Linnæite, smaltite, and cobaltite are silvery-looking minerals not easily distinguishable from some other metallic minerals until they become well known, but erythrite has a beautiful and very characteristic peach-blossom color.

[1] The American localities at which cobalt may possibly be obtained and the uses of cobalt were described in the chapter on cobalt in Mineral Resources for 1912.

MOLYBDENUM.

By Frank L. Hess.

PRODUCTION.

The output of molybdenum ore in 1915 was the largest yet recorded in the United States, but it was still small compared with that of other metals, and only one company, the Arizona Rare Metals Co., seems to have operated steadily through the remainder of the year after having started operations. The production is estimated at 3,498 tons of raw ore. The concentrates and the unconcentrated portion of this ore contained 181,769 pounds of molybdenum and were valued at $114,866. These figures show a total of nearly 91 tons of metal in ores and concentrates, but the loss in smelting is said to be considerable. The output of gold in the United States in 1915 was nearly twice as great in weight, amounting to nearly 168 tons ($101,035,700). At least a part of the molybdenum ore sold is said to have gone to buyers in New York, who placed the material in storage to remain until the close of the European war.

Arizona furnished most of the output of molybdenum. Two operators, the Arizona Rare Metals Co. and Col. Epes Randolph, produced wulfenite, the lead molybdate ($PbMoO_4$), near Tucson. The former concentrated wulfenite from dumps of the Mammoth mine at Mammoth, and the latter took over from A. L. Pellegrin the old Yuma mine, 14 miles northwest of Tucson, which had been worked rather extensively for gold down to the 300-foot level, considerable wulfenite being left in place. The Duquesne Mining & Reduction Co. saved a small quantity of molybdenite (molybdenum sulphide, MoS_2) in mining copper ore from its Bonanza claim at Duquesne, Santa Cruz County, in the Patagonia district, between Nogales and Bisbee, near the Mexican boundary. The Leviathan Mines Co. produced a number of tons of low-grade molybdenite from the Whale claim, near Cedar, Mohave County. The claim is between 25 and 30 miles east of Yucca. The American Molybdenum Co., in the same district, is reported to have put in a concentration plant for treating molybdenum ores toward the close of the year.

In Colorado, the Pingrey Mines & Ore Reduction Co., of Leadville, shipped a considerable quantity of low-grade molybdenite ore from the C. J. Senter claims near Climax, Summit County, and treated it by a flotation process. The Primos Chemical Co. mined a large quantity of low-grade ore at Camp Bocricke, at the head of Clear Creek, in Clear Creek County. The ores were not concentrated before

shipment, and toward the end of the year operations ceased. Henry E. Wood & Co., Denver, Colo., concentrated molybdenite ores shipped from various points.

In Nevada a small lot of rather high-grade concentrates was shipped from Lovelock by R. H. Young.

In Montana a company in the Emigrant district, Park County, is reported to have put up a flotation plant for the treatment of molybdenite, which was about ready to run at the close of the year.

In Texas a shipment of molybdenite-bearing rock for experiments in concentration was made by Kiam & Badu from a pegmatite dike crossing Honey Creek 14 miles southeast of Llano.

In Utah the Alta-Gladstone Mining Co. prospected a vein of molybdenite in granite in Peruvian Gulch, 1½ miles west of Alta. Material extracted carried from 1 to 8 per cent of molybdenum coating the grains of the granite. No ore was sold during the year.

In Washington no production was reported, but active prospecting was stated to be carried on in the Metaline district, near Ione, Pend Oreille County, and on Sheep Mountain, in Okanogan County, 1 mile from the Canadian boundary.

GENERAL CONDITIONS OF THE MOLYBDENUM INDUSTRY.

The molybdenum situation is always very hard to define because the demand is small, most buyers are very secretive about the disposition of their purchases or manufactured products, and inquirers for the ore usually surround their dealings with an air of mystery. There are, however, notable exceptions, men whose courteous helpfulness the United States Geological Survey gratefully acknowledges.

The actual uses as now developed for the metal are small. In this country the use of molybdenum in tool steels, according to reports received by the Geological Survey from various sources, has decreased. A small quantity is used in electric work, for supports for tungsten filaments in incandescent lamps, in Roentgen ray apparatus, and in small resistance furnaces; a number of tons of ore is consumed in making ammonium molybdate for use in chemical work; and a little is used in some stellite; but outside of these practically no uses are known. Efforts have been made to use the blue oxide in dyes, but the process is not known to have been adopted on a commercial scale, although stated in certain papers as a prominent use. Statements that molybdenum is used in smokeless powder, gun steels, and armor plate are constantly reiterated and as positively denied.

Abroad molybdenum is apparently used in steel much more than in this country, and it is commonly accepted that the decided rise in prices was caused by German buyers taking available supplies a few months before the beginning of the war. French and English steel makers are apparently now using the metal to some extent.

The market in this country has heretofore been so small that when a broker is commissioned to purchase 50 tons or more of metal he begins to hunt for a supply, and, as his inquiries go to numerous persons, the impression soon gains ground that there is a large demand. It is reported that molybdenum ore has been purchased with the object of keeping it from other buyers and that the ore has been stored to await the end of the war. The Geological Survey is greatly inter-

ested in seeing an extension of the market and will do what it may in bringing producer and buyer together, but frequently published and inaccurate reports of uses and demands serve no good purpose.

Separate figures showing imports and exports of molybdenite are not compiled by the Bureau of Foreign and Domestic Commerce.

FOREIGN PRODUCTION.

AUSTRALIA.

Queensland is one of the largest producers of molybdenum ore, and in all of its output molybdenite is the ore mineral. The production in 1915[1] amounted to about 109 tons, valued at $219,307. The total yield of Queensland has been 1,230.6 tons, valued at $1,012,808.

New South Wales, lying south of Queensland, is one of the larger producers of molybdenite and in 1915 produced 35.5 short tons of molybdenite, valued at $82,432. The total production has amounted to 533.3 tons.

In 1914, Great Britain commandeered all molybdenum ores on hand or to be produced in British possessions; an embargo was placed on tungsten ores at the same time.

Concerning prices paid Dunstan[2] says:

> In 1915 the prices reached their highest in March at £7 2s. 6d. per unit, which, for 98 per cent ore, would be equivalent to £698 5s. per ton (or $1.51 per pound).
>
> On the 9th of September of the same year, about a year after the beginning of the war, the authorities realized the necessity of controlling the market, and fixed the price at £5 5s. per unit (spot) and £5 (c. i. f.) delivered in London for molybdenite containing from 98 to 96 per cent of sulphide, the first-mentioned price being equivalent to £514 10s. per ton for 98 per cent ore and £504 per ton for 96 per cent ore. The frequently published quotation of £525 per ton would be the value of a ton of ore containing 100 per cent of absolutely pure sulphide, but impurities are always present, so the quotation is misleading.
>
> Ore containing from 90 to 95 per cent of pure sulphide is not considered high grade and is penalized to the extent of about 2s. 6d. per unit, while 85 to 80 per cent ore, still lower in grade, incurs a penalty of 5s. per unit.
>
> Officially recognized buying agents in Queensland vary the price paid according to the place of delivery, the local quotations for ore containing at least 90 per cent of sulphide being as follows: Wolfram, £4 10s. 10d. per unit; Bamford, £4 11s. 1d.; Cairns, f. o. b., £4 11s. 10d.; Townsville, f. o. b., £4 12s. 6d. Delivered in either Sydney or Melbourne, c. i. f., the price is £4 13s. 10d. per unit. From this it will be seen that each per cent of molybdenite, which is equal to 22.4 pounds per ton, would give to a ton of ore a value of about £4 10s., so that with an assay of the ore for percentage, together with a knowledge of the local conditions—such as accessibility of the locality, size of lode, and costs of mining, treatment, and transit—no difficulty should be experienced in estimating the commercial possibilities of any molybdenite-mining proposition.

CANADA.

In Canada, according to McLeish,[3] production has been reported of about 28,600 pounds of molybdenite, valued at $28,460, including cobbed molybdenite and molybdenite contained in ore shipped to concentration plants. There were also about 50 tons of low-grade ore sent to the Mines Branch ore-testing laboratories for experimental concentration. The export of molybdenite was prohibited to other than British destinations except under license, and from September 23 the British Government requisitioned all molybdenite arriving in the United Kingdom at a price of 105 s.per unit of MoS_2, c. i. f. Liverpool, and appointed Messrs. H. A. Watson & Co., Liverpool, as buyers.

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[1] Dunstan, B., Queensland mineral deposits: A review of occurrences, production, values, and prospects: Queensland Govt. Min. Jour., vol. 17, pp. 314,315, 1916.

[2] Op. cit., p. 315.

[3] McLeish, John, Preliminary report on the mineral production of Canada during the calendar year 1915: Mines Branch, Ottawa, p. 15, 1916.

NORWAY.

Norway is a considerable producer of molybdenite, and E. Haldeman Dennison,[1] United States consul general at Christiana, makes this statement concerning the output:

The two principal mines in the country are situated at Knabeheim, near the Kvinas Valley, north of Flekkfjord. Their combined output of concentrate, averaging 75 per cent MoS_2, was 72 tons in 1914 and 87 tons in 1915. The success of these two companies and the demand for molybdenum has resulted in several new companies being formed to exploit and develop the surrounding claims. The two principal companies both use the Elmore vacuum process.

SPAIN.

Spain produces some wulfenite, and in 1915 the output was 29 metric tons, valued at $1,862.[2]

PERU.

Peru [3] produced about 3 tons of molybdenite concentrates, carrying 82 per cent MoS_2.

WORLD'S PRODUCTION.

So far as known the items mentioned above constitute the world's production of molybdenum ore, and from them the world's production in 1915 may be recapitulated thus:

Estimated world's production of molybdenum ores in 1915.

Country.	Ore mineral.	Quantity (short tons).	Estimated percentage of molybdenum.	Weight of molybdenum (short tons).
Canada	Molybdenite	14.3	50	7.2
New South Wales	do	35.5	54	19.2
Norway	do	87.0	45	39.1
Peru	do	3.0	49	1.5
Queensland	do	109.0	54	58.8
Spain	Wulfenite	29.0	20	5.8
United States	Molybdenite and wulfenite	3,498.0	2.6	91.0
				222.6

The world's output of gold in 1915 was about 780 tons ($470,466,214)—more than three and one-half times as much as the 222.6 tons of molybdenum produced.

The losses in the smelting of molybdenum ores are said to be large and have been estimated to be 20 per cent or more.

TESTS FOR MOLYBDENUM.

In identifying minerals a knowledge of their physical characteristics may be as valuable as chemical tests. A short description of molybdenum minerals is therefore given.

Three molybdenum minerals are fairly common—molybdenite, wulfenite, and molybdenum ocher. Molybdenite (molybdenum

[1] Dennison, E. H., Norway: Commerce Repts. Suppl. No. 10b, p. 15, 1916.

[2] Consejo de minería, Estadística minera de España, 1915: Rev. min., met. y de ing., p. 452, Madrid, Sept. 24, 1916.

[3] Quoted from the annual message of the President of Peru, by W. W. Handley, Commerce Repts, 1916, p. 1141. As printed the figures are: "Molybdenum ore of 82 per cent, 274 [metric] tons." A decimal point should make them read: "2.74 [metric] tons."

sulphide, MoS_2), containing 60 per cent molybdenum, occurs in thin, bright, lead-colored flakes, which bend readily but are not elastic and are easily scratched by the finger nail. The flakes may be so minute that they coat a surface like paint, or they may be several inches across, and they may be regularly bounded by straight lines and piled up into doubly terminated hexagonal crystals. The mineral, however, is more likely to be found in irregular lumps, easily cleavable into thin leaves. Its specific gravity is about 4.5.

Molybdenite is associated with many kinds of rocks and veins but occurs most plentifully in association with granitic rocks, especially with granite pegmatites. The deposits are invariably pockety.

Wulfenite (lead molybdate, $PbMoO_4$) contains 39.3 per cent MoO_3. It usually occurs as lustrous resinous yellow, orange, or red tetragonal crystals in the oxidized parts of lead deposits. It may be greenish or brownish, grayish, whitish, or colorless. The crystals are generally platy but may be nearly cubes or double pyramids. The mineral is very brittle. It has a hardness of 2.75 to 3 and a specific gravity of 6.7 to 7.

Molybdenum ocher (hydrous ferric molybdate, $Fe_2O_3.3MoO_3.7\frac{1}{2}H_2O$) generally forms a bright yellow powdery mineral, though it also appears in small radial crystals. It is a weathering product of molybdenite but is probably never found in sufficient quantity to be of commercial value.

Powellite (calcium molybdate, $CaMoO_4$) is a white or grayish mineral formed by the weathering of molybdenite. In some specimens tungsten replaces a part of the molybdenum. Like molybdenum ocher, it is not found in deposits of sufficient size to be of commercial value.

Any of these minerals except molybdenite may be tested by heating a small piece in a porcelain crucible (a particle half the size of a grain of wheat is enough) with a drop of sulphuric acid until the fumes have nearly ceased. When the crucible has cooled, it will have a beautiful deep-blue coating.

Molybdenite must be oxidized before it can be tested in this manner. It may be oxidized either by boiling it to dryness with two or three drops of nitric acid or by powdering and roasting it in the air for a few minutes. The sulphuric acid is then added, and the test is performed as indicated.

PUBLICATIONS.

The following is a list of publications on molybdenum. The Survey publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. All priced publications may be purchased from the Superintendent of Documents, Washington, D. C. Those marked "Exhausted" and others cited herein are not available for distribution but may be seen at the larger libraries of the country.

Calkins, F. C., Molybdenite near Ramona, San Diego County, Cal.: U. S. Geol. Survey Bull. 640, pp. 73–76, 1916.

Crook, A. J., Molybdenite at Crown Point, Wash.: Geol. Soc. Am., vol. 15, pp. 283–288, 1904.

Describes the occurrence, relations to surrounding rocks, and character of molybdenite-bearing veins at Crown Point, Wash.

HESS, F. L., Some molybdenum deposits of Maine, Utah, and California: U. S. Geol. Survey Bull. 340, pp. 231–240, 1908. 30c.

Describes molybdenite deposits near Calais, Me., (previously described by G. O. Smith in Bulletin 260), wulfenite deposits at Alta, Utah, and an economically unimportant molybdenite deposit near Corona, Cal.

HILLEBRAND, W. F., Distribution and quantitative occurrence of vanadium and molybdenum in rocks of the United States: U. S. Geol. Survey Bull. 167, pp. 49–55, 1900. Exhausted.

HORTON, F. W., Molybdenum: Its ores and their concentration, with a discussion of market, prices, and uses: U. S. Bureau of Mines Bull. 111, 132 pp., 1916. 30c.

Describes molybdenum deposits and the molybdenum industry in the United States.

SCHRADER, F. C., Mineral deposits of the Santa Rita and Patagonia mountains, Ariz., with contributions by J. M. Hill: U. S. Geol. Survey Bull. 582, pp. 106–108, 126–127, 173–175, 314–315, 346–348, 1915. 50c.

Contains the same material as the article in Bull. 430.

SCHRADER, F. C., and HILL, J. M., Some occurrences of molybdenite in the Santa Rita and Patagonia mountains, Ariz.: U. S. Geol. Survey Bull. 430, pp. 154–163, 1910. 60c.

SMITH, G. O., A molybdenite deposit in eastern Maine: U. S. Geol. Survey Bull. 260, pp. 197–199, 1905. Exhausted.

Describes molybdenite deposits near Calais, Me.

TIN.

By Frank L. Hess.

PRODUCTION AND DEVELOPMENT.

ALASKA.

The only tin mined and sold in the United States in 1915 was that produced in Alaska and consisted of 102 tons of metallic tin having a value, at the average price of tin for the year, of $78,846. Concerning the production Brooks[1] says:

The York Dredging Co., which is the largest producer, operated its dredge for 87 days on Buck Creek. Its season of operations was somewhat shorter than the normal season, owing to a late spring and early fall. The American Tin Dredging Co. installed a double-flume screen dredge having buckets of 2 cubic feet capacity on upper Buck Creek in 1915. This machine is operated by an 80-horsepower distillate engine and has an estimated daily capacity of 800 cubic yards. The dredge was completed in September and operated for the rest of the open season. The American Gold Dredging Co. operated two dredges on Anikovik River during 1915. One of them is of a double-flume screen type equipped with buckets holding 2 cubic feet; the other is a single-flume dredge with 1¼-foot buckets. The gravels mined by these dredges carry both placer gold and tin. Operations were begun on June 15 and continued until October 15. The four dredges mentioned employed about 50 men. It is reported that some tin-bearing gravels were sluiced on Sutter Creek, which flows into Buck Creek.

Developments were continued at several of the lode-tin properties in the York district during 1915. The noteworthy operations were the continuation of work at the mine of the Jamme syndicate, on Lost River, and on claims of the Bartell's Tin Mining Co. and the United States Tin Mining Co., on the eastern slope of Cape Mountain.

In the Hot Springs district eight operators reported the recovery of small quantities of stream tin incidental to gold placer mining. A churn drill was used extensively during 1915 to prospect for stream tin on Killarney Creek, a tributary of Baker Creek.

SOUTH DAKOTA.

In South Dakota the Black Hills Tungsten Mining & Milling Co. operated a concentrating plant about 4 miles east of Hill City, in which ore carrying about 1.5 per cent tin from the Jolly claims close to Hill City on the east side and additional ore carrying about 2 per cent tin from the Mohawk claim was milled, and a small tonnage of concentrates carrying 61.88 per cent tin was produced but not sold.

NORTH CAROLINA.

In North Carolina the United States Tin Co. carried on some experiments in the concentration of tin ore at Lincolnton, but made no shipments.

[1] Brooks, A. H., The Alaskan mining industry in 1915: U. S. Geol. Survey Bull. 642, p. 28, 1916.

NEVADA.

In Nevada wood tin was found in débris and in place in rhyolite in Lander County, 20 miles north of Battle Mountain. No production has been made from the deposit. The occurrence has been described by Knopf.[1] An interesting fact in connection with the discovery is that stream tin was mentioned by Hoffman[2] as being found in Tuscarora gold placer mines as long ago as 1878. The Tuscarora placers were located in the same range of rhyolite, about 45 miles northeast, and though Hoffman refers to "crystals" of tin being found, it seems probable that the same sort of material may have been meant.

MONTANA.

During 1915 there came to the Geological Survey information that tin had been discovered in a vein of the Leonard mine at Butte, Mont. The mineral which carries the tin is found in a complex of sulphides and has been provisionally called colusite by Reno H. Sales, to whom, through and with Charles W. Goodale, the Geological Survey is indebted for information concerning the occurrence. Mr. Sales writes, under date of December 30, 1915, to Mr. Goodale, as follows:

> Complying with your request I shall try to describe briefly the manner of occurrence of the tin-bearing mineral or substance, which I have named colusite, provisionally.
>
> It was first noted on the 1,200-foot level of the Leonard mine in the Butte district, near the west end of the Piccolo claim; but the Colusa was one of the earliest locations in the district and is included in the Leonard group—hence the name.
>
> It was early noticed, and it is true to-day, that the presence of colusite has an immediate effect on the gold content of the ore. In the general run of Butte copper ores, or copper ore from the Leonard mine other than that containing colusite, the gold content is rarely more than 50 cents per ton, while the copper ore with colusite often runs as high as $2 per ton by carload lot.
>
> I am not prepared to say that this mineral substance colusite is a definite mineral; in fact, the analyses you have made seem to indicate a variable composition. It is just possible that these variations are due to impurities in the samples. The absolutely pure substance is difficult to obtain.
>
> My impression is that colusite has been noticed only in veins belonging to the oldest, or Anaconda, system. It occurs intimately associated with old quartz and pyrite, and there is some evidence that it was one of the very first sulphides to form. In the Leonard and Mountain View South veins, colusite [and] its associated pyrite and quartz have been fractured and the whole mass cemented by later quartz, pyrite, enargite, bornite, and chalcocite. I recall seeing colusite only in the Anaconda vein of the St. Lawrence mine, in the Anaconda or Mountain View South No. 2 vein of the Mountain View and Pennsylvania mines, and in the Shannon or Leonard vein of the West Colusa and Leonard mines.
>
> In vertical range this mineral has been found from the 800 to the 1,800 foot levels of the Leonard. It will, no doubt, extend to much greater depths, but whether it is present to any considerable extent above the 800 I do not know; but it is my belief, however, that it is not. In the Mountain View mine it has been found sparingly from the 800 to the 1,400 levels. In the Leonard occurrence colusite does not appear longitudinally in the vein for a distance of more than 400 feet along the strike, and in the Mountain View South No. 2 vein probably 200 feet along strike would cover it. This extreme localization of the mineral is interesting.

The following analyses of the tin-bearing ore were kindly furnished to the Survey by the same gentlemen:

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[1] Knopf, Adolph, Tin ore in northern Lander County, Nev.: U. S. Geol. Survey Bull. 640, pp. 126-138, 1916.

[2] Hoffman, W. J., On the mineralogy of Nevada: U. S. Geol. and Geog. Survey Terr. Bull., vol. 4, p. 734, 1878.

Analyses of colusite from Butte, Mont.

[Made at the Boston & Montana reduction works of the Anaconda Copper Mining Co., at Great Falls, Mont., in 1913.]

	Leonard mine.	Mountain View mine.		
		1	2	3
Cu	46.1	44.0	45.85	47.1
Fe	1.8	4.2	2.40	2.8
S	28.4	27.3	27.20	30.0
As	6.5	7.1	8.40	8.6
Sb	2.5	1.6	1.50	1.1
Sn	6.6	4.2	5.40	6.0
Zn	Not det.	.46	Trace.	.5
Te	3.1	11.10	0	.3
Bi	Not det.	0	Trace.	.2
Co	Not det.	0	0	0
Ni	Not det.	Trace.	Trace.	0
Mn	Not det.	Trace.	Trace.	Not det.
V_2O_3	Not det.	Not det.	4.07	Not det.
	95.0	99.96	94.82	96.6
Ag, ounces per ton	15.8	Not det.	Not det.	5.5
Au, ounces per ton	7.55	Not det.	Not det.	.12

The mineral is apparently related to, but does not seem to be, stannite, for if the formula for stannite is taken as approximately $Cu_2S.FeS.SnS_2$, the following percentages of the four elements would be required:

	Leonard.	Mountain View.		
		1	2	3
Tin (Sn)	6.6	4.2	5.4	6.0
Iron (Fe)	3.1	2.0	2.5	2.8
Copper (Cu)	7.1	4.5	5.8	6.4
Sulphur (S)	7.1	4.5	5.8	6.5

The item of 4.07 per cent vanadium trioxide in one specimen is very unusual and suggests the presence of a vanadium sulphide.

Mr. Goodale thinks that the deposit will probably not become a source of tin.

BOLIVIAN TIN ORES.

Owing to the closing of German ports by the European war, Bolivian tin ores which had formerly gone to Germany in considerable quantity were without a market. The American Smelting & Refining Co. erected a reduction plant adjacent to its electrolytic copper refinery at Maurer (Perth Amboy), N. J., in which Bolivian tin ores were to be smelted to crude tin and then refined electrolytically, the crude tin being used for anodes and thin sheets of pure tin for cathodes in an electrolyte of hydrofluosilicic acid containing a small quantity of sulphuric acid to keep the lead from going into solution. The plant was nearly ready for operation at the end of 1915. The company expected to be in the market for all American tin ores produced.

The Standard Smelting Co., of Pittsburgh, Pa., was reported by the trade papers [1] to have installed three Wile electric furnaces with the object of smelting Bolivian tin ores.

[1] Iron Trade Rev., Aug. 26, 1915; Waste Trade Jour., Sept. 11, 1915, p. 11.

IMPORTS.

The United States is the greatest user of tin among the nations, using about 40 per cent of the world's production in 1915, and as it is almost a nonproducer, its imports of tin are, of course, large. Hitherto the imports have been almost wholly of smelted tin, but in the next few years ores may be expected to cut a considerable figure in the imports.

The imports as shown below do not include the tin contained in imported ore, tin foil, or other manufactures.

Tin imported and entered for consumption in the United States, 1906–1915.

Year.	Quantity (short tons).	Value.
1906	50,477	$37,447,315
1907	41,257	32,074,263
1908	41,267	23,923,560
1909	47,662	27,558,546
1910	52,528	33,913,255
1911	53,527	43,346,394
1912	58,016	50,372,478
1913	[a] 53,315	46,946,756
1914	[b] 52,919	32,943,059
1915	[c] 68,801	38,854,597

[a] Includes 986 tons of "scrap tin," valued at $19,543.
[b] Includes 5,389 tons of "scrap tin," valued at $61,440.
[c] Includes 11,009 tons of "scrap tin," valued at $117,688.

WORLD'S PRODUCTION OF TIN.

The world's annual production of tin is about equal to the quantity delivered to the market. Though more or less time elapses between the delivery of tin ore to smelters and the placing of the metal on the market, so that the ore produced in the last months of the year does not supply marketable tin until the following year, this delay is fairly well equalized by tin delivered to the market in the first part of the year from ores delivered to the smelters during the previous year.

World's deliveries of tin, 1911–1915, in short tons.

Item.	1911	1912	1913	1914	1915 [a]
London deliveries	17,643	20,823	20,045	23,335	28,168
Continent of Europe	24,671	29,820	28,707	22,747	19,488
Cornwall (production)	5,936	6,160	6,496	6,720	4,256
Bolivia (shipments)	25,312	23,744	27,832	21,000	22,400
South Africa (shipments)	3,248	3,472	3,584	5,600	3,360
China (shipments)	1,680	2,576	2,744	2,128	2,016
United States (receipts)	51,892	57,557	51,017	48,505	54,600
	130,382	144,152	140,425	130,035	134,288
Deductions of Straits, etc., from Continent and English, Bolivian, etc., arriving in the United States.	6,832	9,598	10,416	9,635	.....
	123,550	134,554	130,009	120,400	.....

[a] Metal Statistics, 1916, p. 215.

PRICES.

Average monthly prices, in cents per pound, of Straits tin in New York, 1911–1915.

Month.	1911	1912	1913	1914	1915[a]
January	41.39	43.24	50.425	37.74	34.30
February	42.83	43.46	48.63	39.93	37.32
March	40.76	42.86	46.835	38.08	48.935
April	42.20	44.02	49.12	36.10	47.98
May	43.10	46.12	49.07	33.30	38.78
June	46.16	47.77	44.82	30.65	40.37
July	42.96	44.75	40.27	31.75	37.50
August	43.45	45.87	41.668	50.595	34.39
September	39.98	49.18	42.375	32.79	33.13
October	42.21	50.11	40.41	30.395	33.08
November	43.13	49.90	39.805	33.50	39.375
December	44.97	49.90	37.62	33.60	38.75
Average	42.68	46.43	44.225	35.70	38.66

[a] Metal Statistics, 1916, p. 231.

TESTS FOR CASSITERITE.

The simplest and easiest test for cassiterite is to place a fragment of the mineral in dilute hydrochloric or sulphuric acid with granulated, shot, or sheet zinc. The zinc and the acid rapidly evolve hydrogen, which takes the oxygen from the mineral and leaves a coating of tin on the fragment tested. Granulated zinc is the best to use, as its small particles can be made to touch the specimens at many points and thus bring more of the hydrogen in contact with the molecules of tin-oxide. The reaction is $4H + SnO_2 = Sn + 2H_2O$.

The metallic coating has a dull gray, somewhat leaden appearance, but it may be made lustrous by rubbing with a soft cloth or with the hand. If the hand is used, the characteristic odor given off when tin is rubbed on the flesh may be noted.

This simple and efficient method may be used on crystals or choice specimens without injury to them. The smooth surface of stream-polished wood tin is, however, roughened by this test, owing to the impurities in the mineral, though the surface of ordinary crystalline cassiterite is not noticeably affected. After the test has been made, the coating of metallic tin can be removed by immersing the piece in dilute hydrochloric, sulphuric, or nitric acid.

The blowpipe test is better known and is more often used, though it is not made so readily. The mineral supposed to be cassiterite is pulverized and should yield a light-colored powder unless it is mixed with iron oxides, in which case the powder will be reddish or brown. Some cassiterites from the Carolinas and South Dakota, however, give a purplish powder. A small portion of the powder is mixed with twice its bulk of pulverized charcoal and three times its bulk of sodium carbonate or bicarbonate (ordinary washing or baking soda). The three substances are thoroughly mixed, and a portion the size of a pea is moistened and placed in a hollow in a piece of charcoal. By means of a reducing blowpipe flame tin is readily reduced in small globules, which are easily distinguished from the flux. When cooled the metallic globules may be separated from the soda and will be malleable. If large enough they will emit the characteristic disagreeable odor when rubbed between the fingers and

will yield a white precipitate when treated with concentrated nitric acid. They are soluble in hydrochloric acid, and no precipitate is formed when the solution is cold. These reactions with acids differentiate the metal from lead.

PUBLICATIONS.

The following publications relate to tin deposits in the United States. The Survey publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Washington, D. C. Those marked "Exhausted" and the other publications can be consulted at the large public or university libraries of the country.

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TITANIUM.

By Frank L. Hess.

PRODUCTION.

In 1915 the American Rutile Co. produced 250 short tons of rutile (titanium dioxide) at its plant at Roseland, Va. In the concentration of the rutile, a considerable quantity of ilmenite (titanium iron oxide) was produced as a by-product. The value of both was about $27,500. For many years the company has been the sole producer of rutile in this country. Attempts have been made by others to develop deposits in Hanover and Goochland counties, Va., and near Magnet, Ark., but no commercial production has yet been made at these places.

Rutile and ilmenite are both used in making ferrotitanium, which is employed in making steel and cast iron, and both are used in making electrodes for arc lamps, but for some reason ilmenite from other sources than the Roseland deposits does not seem to give the same satisfaction. Rutile is the source of titanium for making cuprotitanium for use in brass and other copper-bearing alloys and for making potassium titanium oxalate and titanium sulphate for use in dyeing leather and textiles. A little rutile is also used in ceramics.

TESTS FOR TITANIUM MINERALS.

Rutile, octahedrite (anatase), and brookite (all titanium dioxides, TiO_2), are ordinarily glassy and range in color from light brownish yellow or honey-yellow through tints of brown and reddish brown to nearly black. Their streaks are colorless, and their luster is semimetallic. Ilmenite (iron titanium oxide, $FeTiO_3$) gives a dark-brown to black streak.

The easiest test for titanium is to powder and fuse the mineral with sodium carbonate, dissolve in dilute sulphuric acid, and add hydrogen peroxide (H_2O_2). If the solution contains titanium it immediately turns reddish yellow to deep amber, the color assumed depending on the quantity of titanium present.

Another test, which is not so delicate or so satisfactory, is to fuse the mineral with a quantity of sodium carbonate equal to about 6 times its volume, dissolve in strong hydrochloric acid, add a little pure tin, and boil. If the solution contains titanium it will assume a delicate violet color.

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TUNGSTEN.[1]

By Frank L. Hess.

PRODUCTION.

The production of tungsten ores in the United States in 1915 was larger than in any previous year and, according to the figures collected by the United States Geological Survey, was equivalent to 2,332 tons[2] of concentrates carrying 60 per cent WO_3 and valued at about $4,100,000. This production was more than 500 tons larger than the largest previous output, that of 1910, when 1,821 tons was produced, and was nearly two and a half times as much as the production of 1914, which was 990 tons, valued at $435,000, only a little more than one-tenth the value of the output in 1915.

The production from Colorado (963 tons) and from California (962 tons) were equal within the limits of error in the collection of tungsten statistics. Nearly all of Colorado's production was from the Boulder field, and nearly all of California's from the Atolia district. The tungsten production of the United States by ore minerals is unique. Scheelite formed 1,000 tons of the total; ferberite, 960 tons; wolframite, 186 tons; and hübnerite, 178 tons. It is probable that at least 40 tons of the wolframite should be classed as hübnerite, but as no analyses are at hand and as the application of the term hübnerite to the ore mineral has been resented, it will be called wolframite until more definite knowledge is at hand. It seems probable, therefore that wolframite, the commonest tungsten mineral in most countries, is the least common of the commercially valuable tungsten minerals in this country.

The production of tungsten ores in the United States has been as shown in the table given below. The production before 1900 was insignificant.

Concentrated tungsten ores produced in the United States, 1900–1915.[a]

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1900	46	$11,040	1908	671	$229,955
1901	179	27,720	1909	1,619	614,370
1902	184	34,040	1910	1,821	832,992
1903	292	43,639	1911	1,139	407,985
1904	740	184,000	1912	1,330	502,158
1905	803	268,676	1913	1,537	672,118
1906	928	348,867	1914	990	435,000
1907	1,640	890,048	1915	2,332	4,100,000

[a] The production of tungsten ores in this country from year to year can be fairly compared in this table only since and beginning with 1906, as before that date no effort was made to reduce the ores to a common basis of concentration. Since 1906 the ores have been, as far as possible, reduced to an equivalent of ore carrying 60 per cent tungsten trioxide (WO_3), which is the ordinary commercial basis in the United States.

[1] More extended articles on tungsten have been published in Mineral Resources for 1912 and 1914. See also Hess F. L., Tungsten minerals and deposits: U. S. Geol. Survey Bull. 652 (in press).

[2] The ton used in this article, unless otherwise noted, is the short ton of 2,000 pounds.

The production in 1915 was divided among the States as follows:

Tungsten producted in the United States in 1915.

	Short tons.		Short tons.
Arizona	127	South Dakota	140
California	[1] 962	Alaska, Connecticut, Utah, Washington	3
Colorado	963		
Idaho	32		
Nevada	55		
New Mexico	45		2,332

MINING CONDITIONS.

General statement.—Conditions and prices in the tungsten market, which of course governed mining, were unsettled and somewhat anomalous. Although the price late in 1914 was $9 or more a unit,[2] ore carrying 60 per cent of WO_3 was sold in the early part of 1915 as low as $5.80 a unit, so that tungsten mining did not start very briskly. Early in the summer, however, floods of orders for munitions of war caused a great demand for high-speed steels, to be used in cutting shells, rifle barrels, etc.; an embargo was declared by the British Government on the export of tungsten ores from any part of the British possessions; and there was soon a country-wide scramble for tungsten ores. Probably no one foresaw the height to which the price of tungsten would rise, and some operators contracted to deliver ores at prices which in ordinary years would be high but which were soon exceeded by several hundred per cent. Contracts for tungsten metal were also made at prices much below those afterwards reached. In the fall the prices of tungsten ores reached unhead-of heights; $48 per unit was paid for numerous lots, $50 for some, and even higher prices were reported. The prices moved upward so rapidly and unexpectedly that strenuous tungsten prospecting did not follow at once, but early in the fall a large number of men were in the field looking for deposits.

Colorado.—The output of the Boulder field was for various reasons not increased as had been hoped. Many properties had been worked under lease, so that there was no development of ore bodies, for the ore was removed as fast as it was exposed. The output of the district was estimated by the Boulder County Metal Miners' Association as equivalent to 960 tons of 60 per cent concentrates.

Several discoveries of ferberite were reported from Gilpin County, none of which appear to have eventuated in production during the year, and it is alleged that some of the so-called discoveries were salted with ore from the Boulder County veins.

California.—In the Atolia field there were great developments. The Atolia Mining Co. is reported to have employed more than 300 men on its claims, and many men worked the desert sands on other claims in the vicinity for float scheelite. P. J. Osdick discovered rich ore east of the Atolia Mining Co.'s property and made large profits. On and near the Baltic claim a number of men worked the gravel of a shallow gulch for scheelite, and the sands on the Sunshine and other claims are also reported to have been worked at a profit. Several gold mines also produced some scheelite. The Consolidated

[1] Bradley, W. W., California mineral production for 1915: California State Min. Bur. Bull. 71, pp. 8, 37, 38, 1916.

[2] 1 per cent of a short ton in tungsten trioxide (WO_3).

Gold Mines, in Randsburg, had found water at a depth of about 500 feet and this was piped to the Atolia Mining Co.'s mill, about 5 miles distant. Formerly water was hauled on the railroad from wells at Hinkley, a rail distance of about 50 miles to the southeast. The company is reported to have erected a new mill to treat its tailings.

Nevada.—In Nevada the greatest number of discoveries were reported from White Pine County. Scheelite in quartz veins was found at several places between the Minerva district, 30 miles south of Osceola, and Cherry Creek, 50 miles north by northwest. Some and probably most of the veins were prospected for gold and silver years ago, but scheelite was not then recognized. Scheelite was found in the dumps from some of the old workings. The hübnerite mines and mill 12 miles south of Osceola, at the locality formerly known as Hub but rechristened Tungsten, were actively operated toward the end of the season by the United States Tungsten Corporation, the present owner. The scheelite deposit and mill at Camp Bonita, on the east side of the Snake Range, owned by John D. Tilford, were operated under bond and lease by Atkins, Kroll & Co., who also investigated other properties in the region. A mill was erected by the St. Anthony Mines Co. at Toy (Browns), Humboldt County, in which to concentrate the scheelite from the contact-metamorphic deposits near that point, which had been prospected by the company for several years. A mill was erected by A. R. Shepard and associates on the hübnerite deposits in the Regan district, 35 or 40 miles north of Osceola, and another was erected by the Doyle Mining Co. in Sacramento Pass, 10 miles north of Osceola. Some hübnerite was dry washed from desert sands at Round Mountain and Spanish Springs.

New Mexico.—The dumps of gold mines at White Oaks were worked over for hübnerite and yielded a considerable quantity of concentrates, and ore left in mining for gold and silver was taken from the mines.

Arizona.—At Tip Top a mill was under construction to work the tailings and dumps of the old Tip Top silver mine for the wolframite they contain. It was also proposed to extract ore from the mine. Mills were erected by the Primos Chemical Co. at Dragoon, and by the National Tungsten Co. at Arivaca, for treating the tungsten ores at those places; tungsten concentrates were produced at both points, and also at Camp Wood (45 miles west of Prescott), Yucca, Oracle, and Powers Gulch, near Globe.

South Dakota.—At Lead, the Homestake gold mines produced wolframite from the claims west of the great open cut. The Wasp No. 2 mine, 2 miles south, produced a considerable quantity of ore and began the construction of a concentration plant. Only a few hundred pounds of concentrates were produced in the southern part of the Black Hills.

Idaho.—In Idaho a little hübnerite was produced in the Blue Wing district on Patterson Creek, near Patterson, Lemhi County; a little ferberite (?) near Corral, Blaine County; and a little scheelite at Murray.

Alaska.—In Alaska a few hundred pounds of scheelite was picked out of the concentrates from the gold placers, and scheelite was discovered in regionally metamorphosed limestone 15 miles northeast of Fairbanks, near the head of Chatham Creek.

Washington.—In Washington the wolframite deposits on Tungsten Peak, near Cathedral Peak, 45 miles northwest of Oroville, became the property of the Tungsten Mines Co., and the new owner produced a small quantity of ferrotungsten in an electric furnace at Tacoma.

PRICES.

In 1914 the tungsten industry had been temporarily nearly paralyzed by the beginning of the European war, but before the end of the year $9 or more a unit was paid for ores carrying 60 per cent WO_3. The demand was not steady, however, and early in 1915 ores were sold as low as $5.80 a unit, so that many properties were idle. As already stated, large orders from Europe for munitions caused a sudden inflation of prices until $40 a unit was a common price and more than $50 a unit was reported. Some producers were tied up with contracts at low prices, and had it not been for this fact values would have shown a still greater total.

The price of tungsten as metal or ferrotungsten rose from $1 a pound in January to $8 a pound in December. In the same period tungsten steels increased in price from 60 or 75 cents to $3 a pound.

WORLD'S PRODUCTION OF TUNGSTEN.

As stated in the report for 1914, economic conditions have been so disturbed by the European war that it is difficult to obtain figures for the tungsten produced in several countries for years later than 1912. Estimates based on the available data have been made for each country. Mexico became a producer of tungsten ores for the first time in 1915. Where authorities are not cited in footnotes to the table, they have been quoted in preceding years.

The world's production of tungsten ore, 1906–1915, by countries, estimated as far as possible in short tons of concentrates containing 60 per cent of tungsten trioxide.

Country.	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Africa: South Africa	9	211	40	16	(a)	(a)	(a)	(a)	(a)	[b]1
Asia:										
Burma and the Shan States					407	1,119	2,095	1,905	2,055	[c]3,010
Federated Malay States	151	89	83	99	105	205	275	273	317	[d] 353
French Indo-China (Tonkin)					19		81	[e]100	[f]119	[f]219
India (not including Burma)				7	23			(a)	(a)	(a)
Japan	47	71	220	292	275	287	225	327	226	[g]478
Siam		10				200	200	1	33	[h]79
Trengganu (Malay Peninsula)									173	[e]175

[a] No tungsten ore produced so far as can be learned.

[b] Tenth annual statement of the trade and shipping of the colonies and territories forming the South African Customs Union, Cape Town, 1916. Wolframite.

[c] Rangoon Gazette, Sept. 26, 1916. A copy of the article was forwarded by W. R. Dorsey, American consul at Rangoon. The figures given include 39,432 hundredweight from the Tavoy district under the mines act of 1901; 6,861 hundredweight 25 pounds from the Tavoy, Mergui, and Thaton districts from mines and quarries less than 20 feet deep, and 6,614 hundredweight of wolframite and cassiterite from the southern Shan States, which are supposed to contain about equal quantities of the two minerals. The concentrates are treated as carrying 65 per cent WO_3, the British Government standard, though much of the output has averaged 67.5 per cent WO_3.

[d] Scrivenor, J. B., Address delivered before the Chamber of Mines at Ipoh, Perak, Mar. 25, 1916; quoted in Min. Mag. [London], vol. 14, p. 347, 1916. The figures were given in long tons as: Selangor, 158 tons of wolframite and 53 tons of scheelite; Negri Sembilan, 75 tons of wolframite; Perak, 48 tons of wolframite and 4 tons of scheelite; total, 291 tons. The ores have been considered as carrying 65 per cent WO_3.

[e] Estimated.

[f] Briggs, L. P., French Indo-China: Commerce Repts. Suppl. No. 54a, p. 20, Oct. 16, 1916. As given the figures are: Tin and tungsten [minerals] exported in 1914, 216 metric tons; in 1915, 397 metric tons. The tungsten (wolframite) ore has arbitrarily been taken as a half of the conbined tin-tungsten ores exported.

[g] Kirjassof, M. D., Commerce Repts., Aug. 25, 1916, p. 321. Exports only. As given the figures are: 409 [metric?] tons, averaging 65 per cent WO_3. Probably includes ore from Korea and possibly some from Manchuria. Both wolframite and scheelite are mined, but wolframite is in excess.

[h] The foreign trade and navigation of the port of Bangkok, years 2457 (1914–15) and 2458 (1915–16), p. 69, 1916. (The Siamese year is from Apr. 1 to Mar. 31.) As given the figures are: Total exports, 1,092.9 piculs. Of this quantity 924.9 piculs was exported to the United States and the remainder, 168 piculs, went to Japan. The ore mineral is wolframite and the concentrates contain some cassiterite (tin oxide).

The world's production of tungsten ore, 1906–1915, by countries, estimated as far as possible in short tons of concentrates containing 60 per cent of tungsten trioxide—Continued.

Country.	1906	1907	1908	1909	1910	1911	1912	1913	1914	1915
Australia:										
New South Wales	270	451	269	431	413	512	298	220	244	[a] 109
Northern Territory	230	177	40	49	78	71	44	[b] 42	[c] 50	[c] 50
Queensland	865	703	516	679	1,145	750	944	587	442	[d] 708
Tasmania	22	46	5	20	75	86	87	89	[e] 61	[f] 150
Victoria	.....	.....	3	15	31	33	13	1	(g)	(g)
Western Australia	1	5	.....	1	2	12	(g)	1	1	(g)
East Indies:										
Billiton	.....	4	11	12	21	.....	21	[c] 20	[c] 20	[c] 20
Singkep	.....	1	14	12	12	.....	8	[c] 10	[c] 10	[c] 10
Europe:										
Austria	63	50	44	43	54	50	73	[c] 75	[c] 75	[c] 75
England	304	361	261	421	307	298	216	204	230	[h] 399
France	20	67	124	55	33	188	252	[c] 300	[c] 300	[c] 300
German Empire (Saxony)	57	68	46	106	105	89	111	[c] 150	[c] 150	[c] 150
Italy	28	18	.....	.....	(g)	(g)	(g)	(g)	(g)	(g)
Portugal	629	702	684	609	1,132	1,078	1,466	900	[c] 1,000	[c] 1,200
Spain	222	303	249	142	169	106	202	179	[c] 175	[i] 611
Oceania: New Zealand	121	153	87	78	187	184	181	297	274	[j] 261
North America:										
Mexico	.....	.....	.....	.....	.....	.....	.....	.....	.....	[k] 115
Nova Scotia	.....	.....	.....	.....	83	(g)	17	12	(g)	(g)
United States	928	1,640	671	1,619	1,821	1,139	1,330	1,537	990	2,332
South America:										
Argentina	326	507	548	900	826	683	702	591	[l] 482	[l] 189
Bolivia	75	500	187	168	232	370	547	328	320	[m] 902
Brazil	.....	.....	16	(g)	(g)	(g)	(g)	(g)	(g)	(g)
Peru	.....	.....	.....	.....	15	57	241	327	130	[n] 433
	4,367	6,137	4,113	5,774	7,570	7,517	9,654	8,476	7,877	12,328

[a] New South Wales in 1915: Min. Jour. [London], vol. 114, p. 597, 1916. The figures given are: 187 [long] tons of wolfram and scheelite in 1914 and 83 [long] tons in 1915. The ores are supposed to be of the usual Australian standard, 70 per cent WO_3.

[b] Knibbs, G. H., Official yearbook of the commonwealth of Australia. Statistics for the period 1901–1914, p. 994, 1916. Only the value of the output is given, £3,140. The tonnage has been estimated from this on the basis that in 1912, 44 short tons were valued at £3,330. Wolframite.

[c] Estimated.

[d] Under Secretary for Mines, Queensland mining industry, review of the year 1915: Queensland Govt. Min. Jour., vol. 17, p. 117, 1916. As given the figures are: Wolfram, 416 long tons 6 hundredweight, valued at £54,300; scheelite, 2 long tons, valued at £117; mixed bismuth and wolfram, 246 long tons, 18 hundredweight, valued at £26,003. The bismuth-wolframite concentrates are arbitrarily treated as being half wolframite carrying 70 per cent WO_3.

[e] Tasmania in 1914: Mining Jour. [London], vol. 111, p. 751, Oct. 30, 1915. As given the figures are 47 long tons of wolframite, presumed to carry 70 per cent WO_3.

[f] Estimate based on Mills, Loftus, Tungsten and molybdenum: Geol. Survey (Tasmania) Min. Res. No. 1, pt. 1, p. 30; pt. 2, p 13, 1916. Mills states that the production at the time of writing was at a monthly rate of 13 long tons of concentrates carrying 70 per cent WO_3. This is at the rate of 204 short tons of 60 per cent concentrates a year. Wolframite.

[g] No tungsten ore produced so far as can be learned.

[h] Home Office, advance report, quoted in Min. Jour., vol. 113, p. 3, May 13, 1916. Given as 329 [long] tons of wolframite. Thought to carry about 65 per cent WO_3.

[i] Revista min., met. y de ing., vol. 67, p. 452, Sept. 26, 1916. The figures as given are 511.3 metric tons, valued at 218,321 pesetas. The figures are treated as representing concentrates carrying 65 per cent WO_3. Wolframite.

[j] Winslow, A. A., United States consul general at Auckland, New Zealand. Given as 194 long tons, valued at $135,211. Supposed to carry 72 per cent WO_3. Scheelite.

[k] Imports for consumption in the United States, 103 gross tons. This is thought to have been scheelite from Yaqui River, Sonora.

[l] For 1914: Estadística minera de la república, ano 1914: Ministerio agr. de la nación, Dir. gen. minas, geol. e hidr. Bol. 7, p. 37, 1916. The figures are 409 metric tons, containing 362.127 tons WO_3.

For 1915: Robertson, W. H., Commerce Repts., No. 120, p. 702, May 22, 1916. Exports, 158 metric tons of wolframite carrying about 65 per cent WO_3.

[m] Figures furnished by the Pan American Union. As given the figures were 755 metric tons carrying 65 per cent WO_3.

[n] Handley, W. W., Mineral production of Peru: Commerce Repts., 1916, p. 1141. The figures given are 371 metric tons, 65 per cent [WO_3], valued at $350,358. Hübnerite.

In the British possessions the price of tungsten ores was fixed at 55s. per long ton unit, apparently laid down in England, for the Australian papers contain advertisements announcing that payments would be made as follows: Either wolframite or scheelite ores carrying 65 per cent or more of WO_3 from 45s. 2d. to 48s. 1d., the price depending on the field. For ores carrying between 60 and 65 per cent WO_3 a penalty of 3d. for each unit (presumably below 65 per

cent), and for ores carrying between 55 and 60 per cent 6d. penalty for each unit (below 65 per cent ?).

The base price of 55s. per long ton unit for 65 per cent ore is equivalent to $12.03 per short ton unit, the unit used in the United States. For 60 per cent ore, the standard here, the British price falls to $11.69 a unit in England. In the various camps of Australia the price falls as low as $9.58 per short ton unit for 60 per cent ore.

The British price was not fixed until the price of ores had risen to a high point, and the difference between the fixed price and the market price is virtually a tax of that amount on the miner. The requirement that ores must carry 65 per cent WO_3 really adds a further tax, because each added percentage of purity causes a disproportionately larger loss in milling.

IMPORTS.

In 1915, as shown by the figures compiled by the Division of Statistics of the Bureau of Foreign and Domestic Commerce, the imports of tungsten-bearing ores for consumption amounted to 1,534 tons, valued at $1,044,986. There is no duty on tungsten ores.

FIELD TEST FOR TUNGSTEN.

In general, tungsten minerals are found in regions of granitic rocks, though some are found where the granular rocks do not appear at the surface in close connection with the veins. The tungsten produced in the United States and in other countries is obtained almost wholly from areas of quartzose granular igneous rocks or from areas intruded by them.

The mineral to be tested should first be finely pulverized and then digested with hydrochloric (muriatic) acid. This test may be made in any receptacle which is not attacked by the acid—a tumbler, bottle, teacup, or test tube. If the mineral is scheelite the digestion will need to be carried on but a few minutes, but wolframite, hübnerite, or ferberite should be boiled for 10 to 20 minutes, or be heated to a lower temperature for a longer time. If the specimen tested contains tungsten minerals, a yellow powder, tungsten trioxide (WO_3), will be produced, though it may be masked by iron or other impurities. On the addition of metallic zinc the solution will turn indigo blue if sufficient tungsten trioxide has been formed. The depth of the color, and even the color itself, will depend largely on the extent of the digestion and the quantity of tungsten in the specimen tested. If only a little tungsten trioxide has been formed, the blue will be light, or even indistinguishable, and will be followed by violet and later by brown. If a considerable quantity of the trioxide has been formed, the blue will be very deep and the violet will probably not appear, a muddy brown color succeeding the blue more or less quickly. Metallic tin, a piece of "tin" from a "tin" can, or even a piece of solder may be used instead of zinc, but they do not act so readily, and the reactions, except with pure tin, are not always so satisfactory.

PUBLICATIONS.

The following publications relate to the tungsten deposits of the United States. The Survey publications, except those to which a

price is affixed, may be obtained free by applying to the Director United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Washington, D. C. The other publications listed are not available for distribution by the Survey, but may be consulted at the larger libraries of the country.

Bancroft, Howland, Notes on tungsten deposits near Deer Park, Wash.: U. S. Geol. Survey Bull. 430, pp. 214–216, 1910. 60c.

——— The ore deposits of northeastern Washington: U. S. Geol. Survey Bull. 550, pp. 29, 111–123, 130–133, 1914.

Describes tungsten deposits in Cedar Canyon and Deer Park areas, Stevens County, Wash.

Bastin, E. S., and Hill, J. M., Preliminary report on the economic geology of Gilpin County, Colo.: U. S. Geol. Survey Bull. 620, pp. 295–323 [tungsten ores, p. 311], 1916.

Gives very brief mention of the ferberite deposits of Boulder County, Colo.

Blake, W. P., Hübnerite in Arizona: Am. Ins. Min. Eng. Trans., vol. 28, pp. 543–546, 1899.

Describes the hübnerite deposits at Dragoon, then newly found.

Collier, A. J., The tin deposits of the York region, Alaska: U. S. Geol. Survey Bull. 229, pp. 41, 54–55, 1904. 15c.

The occurrence of wolframite on Tin Creek is mentioned.

George, R. D., and Crawford, R. D., The main tungsten area of Boulder County, Colo.: Colorado Geol. Survey First Rept., 1908, pp. 7–103, 1909.

Describes the ferberite deposits of Boulder County, Colo.

Hess, F. L., Note on a tungsten-bearing vein near Raymond, Cal.: U. S. Geol. Survey Bull. 340, p. 271, 1908. 30c.

The deposit has no economic value.

——— Tin, tungsten, and tantalum deposits of South Dakota: U. S. Geol. Survey Bull. 380, pp. 131–163 [tungsten, 149–157], 1909. 40c.

Describes tungsten deposits near Hill City and Lead, S. Dak.

——— Note on a wolframite deposit in the Whetstone Mountains, Ariz.: U. S. Geol. Survey Bull. 380, pp. 164–165, 1909. 40c.

The deposit described has peculiar interest to students of ore deposits as it appears to be a segregation from granite like the schlieren of biotite and similar dark minerals at other localities.

——— Tungsten minerals and deposits: U. S. Geol. Survey Bull. 652 (in press).

A general article describing tungsten minerals, accompanying minerals, and characteristics of tungsten deposits, with other data on tungsten.

Intended to be of service to prospectors and others interested in the subject. The work is illustrated by colored and black and white plates.

——— and Schaller, W. T., Colorado ferberite and the wolframite series: U. S. Geol. Survey Bull. 583, 75 pp., 1914. 20c.

A study of the mineralogy of the ferberite of Colorado and the related tungsten minerals, hübnerite and wolframite.

Hill, J. M., Note on the occurrence of tungsten minerals near Calabasas, Ariz.: U. S. Geol. Survey Bull. 430, pp. 164–166, 1910. 60c.

——— Notes on some mining districts in eastern Nevada: U. S. Geol. Survey Bull. 648, pp. 38, 41, 42, 62–63, 206–207, 1916.

Describes contact-metamorphic deposits carrying scheelite in the Ruby Range near Ruby Valley post office, Elko County (pp. 62–63), and the hübnerite deposits at Tungstonia in the Regan district, in the Kern Mountains, White Pine County (pp. 206–207).

Hobbs, W. H., The old tungsten mine at Trumbull, Conn.: U. S. Geol. Survey Twenty-second Ann. Rept., pt. 2, pp. 7–22, 1901. $2.25.

——— Tungsten mining at Trumbull, Conn.: U. S. Geol. Survey Bull. 213, p. 98, 1903. Exhausted.

Irving, J. D., Some recently exploited deposits of wolframite in the Black Hills of South Dakota: Am. Inst. Min. Eng. Trans., vol. 31, pp. 683–695, 1902.

Describes the general geology and occurrence of wolframite in the vicinity of the Homestake, Wasp No. 2, and other gold mines near Lead, S. Dak.

Johnson, B. L., Occurrence of wolframite and cassiterite in the gold placers of Deadwood Creek, Birch Creek district [Alaska]: U. S. Geol. Survey Bull. 442, pp. 246–260, 1910. 40c.

KNOPF, ADOLPH, Geology of the Seward Peninsula tin deposits [Alaska]: U. S. Geol. Survey Bull. 358, pp. 38, 55–58, 1908.

Briefly describes the occurrence of wolframite on Tin Creek, and scheelite in contact metamorphosed limestone on Cape Mountain.

——— Tungsten deposits of northwestern Inyo County, Cal.: U. S. Geol. Survey Bull. 640, pp. 229–255, 1917.

Describes the contact metamorphic deposits carrying scheelite, near Bishop, Cal.

LINDGREN, WALDEMAR, Some gold and tungsten deposits of Boulder County, Colo.: Econ. Geology, vol. 2, pp. 453–463, 1907.

MCKENNA, R. C., Mining tungsten ores in Colorado: Iron Trade Rev., Dec. 30, pp. 1280–1282, 1915.

O'HARRA, CLEOPHAS, Mineral wealth of the Black Hills, S. Dak.: South Dakota Geol. Survey Bull. 3, pp. 67–72, 1902.

RICHARDS, R. W., The Dragoon, Ariz., tungsten deposits: Min. Sci., vol. 57, pp. 93–94, 1908.

RICKARD, FORBES, Notes on tungsten deposits in Arizona: Eng. and Min. Jour., vol. 78, pp. 263–265, 1904.

Describes the hübnerite deposits at Dragoon, Ariz.

SCHRADER, F. C., Mineral deposits of the Santa Rita and Patagonia mountains, Ariz.: U. S. Geol. Survey Bull. 582, pp. 353–355, 1915. 50c.

Practically a reprint of the article by Hill in Bull. 430.

SMITH, F. D., The Osceola, Nev., tungsten deposits: Eng. and Min. Jour., vol. 73, pp. 304–305, 1902.

Describes the hübnerite deposits 12 miles south of Osceola, Nev.

UMPLEBY, J. B., Geology and ore deposits of Lemhi County, Idaho: U. S. Geol. Survey Bull. 528, pp. 73–74, 77, 79, 109–112, 1913.

Describes briefly the occurrence of hübnerite on Patterson Creek, Lemhi County, Idaho.

WEEKS, F. B., An occurrence of tungsten ore in eastern Nevada: U. S. Geol. Survey Twenty-first Ann. Rept., pt. 6, pp. 319–320, 1901. $1.

Describes the hübnerite deposits 12 miles south of Osceola, Nev.

——— Tungsten ore in eastern Nevada: U. S. Geol. Survey Bull. 213, p. 103, 1903. Exhausted.

Practically the same article concerning the hübnerite deposits 12 miles south of Osceola, Nev., as that in the Twenty-first Ann. Rept.

——— Tungsten deposits in the Snake Range, White Pine County, eastern Nevada: U. S. Geol. Survey Bull. 340, pp. 263–270, 1908. 30c.

Further data concerning the Osceola deposits obtained at a later visit to them.

WINCHELL, A. N., Mining districts of the Dillon quadrangle, Mont., and adjacent areas: U. S. Geol. Survey Bull. 574, p. 125, 1914.

Describes the quartz veins near Pony, Mont., which carry hübnerite and grade into pegmatite.

RADIUM, URANIUM, AND VANADIUM.

By Frank L. Hess.

PRODUCTION.

Radium, uranium, and vanadium are closely connected in occurrence in the principal fields, Colorado and Utah. In 1915 the European war caused a great decline in the production of ores of radium and uranium, but it caused a considerable increase in the production of ores of vanadium

According to reports received by the United States Geological Survey the output was 47,000 tons of ore containing 19.9 tons of uranium and 6.1 grams of radium contained in the carnotite ores produced and 627 tons of vanadium contained in the carnotite ores shipped and in the chemical concentrates from the roscoelite ores. The vanadium is arbitrarily valued at $600,000, though the vanadium in the carnotite ores was practically without value in the ore and the roscoelite was all mined and reduced by the owner, the Primos Chemical Co., so that it would probably be difficult for the company itself to assign a value to the ore. The uranium ores were valued at $93,750, which covered the value of the uranium and radium contained. In 1914 the ores produced contained 87.2 tons uranium oxide (U_3O_8) containing 74 tons of uranium, 22.3 grams radium, and 435 tons vanadium. Nearly all of the ores were from Colorado.

The United States has much the largest known radium-bearing deposits of the world, but European municipalities and hospitals have been buying and utilizing most of the radium produced. When the war began, therefore, causing European money to flow into other channels, the demand for radium fell off so greatly that there was practically no market for radium or uranium ores in the early part of 1915, and very little market during any part of the year. Mining of carnotite ores, except by the National Radium Institute (Inc.) under the supervision of and in cooperation with the Bureau of Mines and except for such work as was necessary for assessment work to hold claims, was nearly stopped.

The Radium Institute mined nearly the 1,000 tons of ore called for by its contract with the Crucible Steel Mining & Milling Co.'s claims in Long Park, Montrose County, Colo., and obtained 70 tons of concentrates, carrying about 3 per cent of uranium oxide, by concentrating material carrying 0.7 per cent which had been thrown on the dumps. The institute fully accomplished its purpose to work out a practical process of producing radium at a cost much below the market price of the element, and crystallized radium salts containing 6 grams of the element. It delivered during the year 3.006 grams of

radium (element) at a cost of $37,599 per gram. Near the end of the year a private company contracted for 1.1 grams of radium (element) for $132,000, or $120,000 a gram. This comparison shows the great success of the work of the Bureau of Mines. Its method of concentrating ore seems to have been highly successful also. After mining its quota of ore from the Crucible Steel Mining & Milling Co.'s property, the institute came into the market as a purchaser of ore.

In the second half of the year Dr. W. A. Schlesinger and associates established a radium-reduction plant in Denver. They acquired an interest in the Copper Prince claims, from which ore was mined, and bought additional ore. Ore carrying about 5,000 pounds of uranium oxide, containing about 640 milligrams of radium, was treated during the year.

The Carnotite Reduction Co., made up of Dr. H. N. McCoy, of the University of Chicago, and associates, purchased from Galloway & Belisle a quantity of ore that had been stored in Placerville, Colo., the radium from which was to be extracted in Chicago. The company will mine ore from claims it has bought.

The Standard Chemical Co. did no work on its claims except that required by law, but in this work produced and shipped a quantity of ore from its properties in Colorado and Utah, and purchased, it is stated, a considerable number of claims. It was reported in December that the company had produced a total of 14 grams of radium (elemental) and that its ore had averaged 1.7 per cent uranium oxide. Probably between 4 and 5 grams of this quantity was produced during 1915.

The production of radium salts in this country during the year was probably nearly 11 grams.

Only a small quantity of ore is thought to have been exported during the year. J. S. McArthur & Co. shipped one lot of ore from claims near Greenriver, Utah, to Glasgow, Scotland.

The Primos Chemical Co. mined most of the roscoelite-bearing sandstone from which it obtains its vanadium from its claims on Bear Creek about 2 miles south of the plant at Vanadium (formerly called Newmire), where the ore is given a chloridizing roast and lixiviated and the vanadium is precipitated as iron vanadate, which is shipped to the East for reduction to ferrovanadium. Smaller quantities of ore were mined from deposits high up the steep hill behind and about a mile from Placerville, whence it was packed down to the railroad at Placerville on burros and mules and shipped to Vanadium, a distance of about 9 miles.

The workings on Bear Creek are extensive, and it is reported that about 75 tons daily was produced from them. The "No. 6" workings are said to have extended into the hill more than 2,100 feet, though not in ore all the way. The roscoelite is in flat veins not over an inch thick lying along horizontal bedding planes, and the sandstone is impregnated from it, both above and below, through a thickness which has reached more than 30 feet, though usually much less.

The flat beds of sandstone containing the roscoelite are cut through by Bear Creek, which has a moderately steep gradient, so that although at the mouth of the creek the horizon of the vanadium-bearing bed is several hundred feet above the creek, 2 miles upstream the creek bed and the ore bed are at the same level. Slightly above

this point the company sought for the ore bed with diamond drills, and, the Survey is informed, found it between 300 and 400 feet below the valley floor. A vertical shaft was started but struck crushed ground probably indicating faulting. The vertical shaft is said to have been abandoned, and an incline more than 1,100 feet long, with a slope of 25 degrees, was driven from a point a little way down the creek.

The Omega tunnel, east of Placerville, was in over 200 feet and that on the Vanadis No. 1 about 400 feet.

In the spring the company placed a steam plant and compressor at Sawpit to furnish compressed air to workings in the deposits which lie in the bluff on the opposite side of and several hundred feet above San Miguel River.

It is reported that practically all the claims near Sawpit and claims on Fall Creek formerly operated by others have now been acquired by the Primos Chemical Co. and that it has done thousands of feet of drifting on the various claims. During the year the company is said to have employed more than 175 men at its various workings and at the reduction plant at Vanadium.

THE APPEARANCE OF RADIUM.

The Geological Survey has received numerous inquiries about the appearance of radium, many of which seem to have been prompted by carelessly written stories appearing in periodicals of the poorer class; these stories tell of remarkable finds of nearly pure radium.

Radium is a metal, and is described as having a white metallic luster. It has been isolated only once or twice, and few people have seen it. Radium is ordinarily obtained from its ores in the form of hydrous sulphate, chloride, or bromide, and it is in the form of these salts that it is usually sold and used. These are all white or nearly white substances, whose appearance is no more remarkable than that of common salt or baking powder. Radium is found in nature in such exceedingly small quantities that it is never visible even when the material is examined with a microscope. Ordinarily radium ore carries only a small fraction of a grain per ton of material, and radium will never be found in large masses because it is formed by the decay of uranium, a process which is wonderfully slow, and radium itself decays and changes to other elements so rapidly that it is impossible for it to accumulate naturally in visible masses. Radium and radium minerals are not generally luminescent. Tubes containing radium glow from impurities present which the radiations from the radium cause to give light.

Minerals that carry radium are fairly easy to determine, for they affect photographic films in the same way as ordinary light, and they can also be identified by their effect upon an electroscope.

TESTS FOR URANIUM-RADIUM MINERALS.

All minerals that carry uranium also carry radium, which is now considered a product of the atomic decomposition of uranium. A test for radioactivity is, however, not a conclusive test for radium and uranium, for thorium also has a decomposition product, mesothorium, which closely resembles radium in its behavior.

Tests for radioactivity will therefore show only whether the specimen contains radium and uranium or mesothorium and thorium. The appearance of the minerals will generally determine which of the elements is present, but in case of doubt the determination requires more elaborate tests, which should be made by an experienced chemist.

To test for radioactivity lay the mineral to be tested on a plate holder containing a sensitive photographic plate, and if uranium is present in any considerable quantity the plate will be light-struck within a period ranging from 12 hours to a week, the time depending on the quantity of radioactive matter in the specimen.

When objects are laid directly upon a sensitized film or plate deceptive effects are obtained by pressure. Many supposed "radiographs" made by mere pressure have been sent to the Survey. In some of these the sensitized coating has been entirely removed under the object and the remainder was so light-struck that the experimenter thought he had obtained a "reversed" effect.

CONSTANTS OF RADIUM, URANIUM, AND VANADIUM.

It is not easy to keep in mind the figures necessary for estimating the quantity of radium, uranium, or vanadium present in a mineral or ore of given tenor, so the constants most used in such estimates are given below.

Atomic weights: Br, 79.92; Cl, 35.46; O, 16; Ra, 226.4; U, 238.5; V, 51.

Molecular weights and ratios: UO_3, 286.5 = 1.201 U; U = 0.8325 UO_3; U_3O_8, 844 (843.5) = 1.179 U_3; U_3, 715.5 = 0.8483 U_3O_8; V_2O_5, 182 = 1.784 V_2; V_2, 102 = 0.56 V_2O_5. The ratio of U_3O_8 to V_2O_5 in carnotite or tyuyamunite $(K_2,Ca)O.2UO_3.V_2O_5 + 8\,?H_2O$, is 3.09 to 1; that is, there is 3.09 times as much U_3O_8 as V_2O_5. The ratio of uranium to vanadium in carnotite or tyuyamunite is 4.68 to 1. The ratio of the molecular weight of hydrous radium bromide, $RaBr_2\,2H_2O$, 422.2, to the radium it contains is 1.865 to 1, or the radium is equal to 0.5362 of the hydrous radium bromide.

Gross weights: 1 ton U_3O_8 contains 1,697 pounds (769.75 kilos) of uranium.

"One gram radium is present in a quantity of mineral containing 3,000 kilos of uranium."[1] Therefore one-third of a milligram of radium is present in 1 kilo of uranium (1 kilogram = 2.2046 pounds; 1 short ton (2,000 pounds) = 907.194 kilograms).

One ton of uranium (elemental) contains 302.4 milligrams of radium.

One ton of U_3O_8 contains 256.58 milligrams of radium.

One ton of ore containing 1 per cent of U_3O_8 carries 2.566 milligrams of radium (elemental), equivalent to 4.787 milligrams hydrous radium bromide.

TESTS FOR VANADIUM.

Most of the vanadium minerals, especially those of the oxidized zone, are readily soluble in mineral acids. Hydrochloric is the most convenient acid to use. If concentrated hydrochloric acid, HCl, is put upon carnotite, uvanite, vanadinite, the descloizites, and some

[1] Rutherford, E., Radioactive substances and their radiations, p. 462, Cambridge, Mass., University Press, 1913.

other vanadium minerals, it immediately gives a rich red-brown solution. If water is added the color changes to green or disappears. If the dilution is not too great the brown color reappears on the addition of hydrogen peroxide (H_2O_2). If metallic zinc is added the green color will again appear and may gradually fade until the solution becomes colorless.

Calcium vanadate and a few other oxidized minerals do not show the brown-red color at once, but must be treated with the acid for a longer time. Heating will hasten the reaction.

If dilute acid is used the solution is ordinarily greenish, yellowish (from uranium), or nearly colorless. The addition of hydrogen peroxide gives the reddish-brown color, and added zinc will again bring the green color or decolorize the solution. Vanadium-bearing silicates, such as roscoelite, may be treated with dilute acid and either be allowed to stand for some time or be boiled, after which good reactions may be obtained.

With carnotite, vanadinite, the descloizites, and some other minerals, it is only necessary to place a drop of concentrated hydrochloric acid upon the mineral to get the rich red-brown color almost immediately. The addition of 2 or 3 drops of water makes the color change to light green or disappear.

PUBLICATIONS.

The following is a list of publications on radium, uranium, and vanadium. The Survey publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The Bureau of Mines publications, unless the stock has been exhausted, may be obtained free by applying to the Director, Bureau of Mines, Washington, D. C. All priced publications may be purchased from the Superintendent of Documents, Washington, D. C. Those marked "Exhausted," and other publications cited herein are not available for distribution, but may be consulted at the larger libraries of the country.

Bastin, E. S., Geology of the pitchblende ores of Colorado: U. S. Geol. Survey Prof. Paper 90, pp. 1–5, 1915. 40c.

Bastin, E. S., and Hill, J. M., Preliminary report on the economic geology of Gilpin County, Colo.: U. S. Geol. Survey Bull. 620, pp. 295–323 [uranium ores, pp. 310–311], 1916.

Boutwell, J. M., Vanadium and uranium in southeastern Utah: U. S. Geol. Survey Bull. 260, pp. 200–210, 1905. Exhausted.

Curie, P. (Mme.), Traité de radioactivité, vol. 1, 426 pp., vol. 2, 548 pp., numerous figures and 8 plates, Paris, Gauthier-Villars, 1910.

This is the monumental work of the discoverer of radium.

Fleck, Herman, and Haldane, W. G., A study of the uranium and vanadium belts of southern Colorado: Colorado State Bureau of Mines Rept., 1905–6, pp. 47–115, 1907.

Gale, H. S., Carnotite in Rio Blanco County, Colo.: U. S. Geol. Survey Bull. 315, pp. 110–117, 1907. Exhausted.

——— Carnotite and associated minerals in western Routt County, Colo.: U. S. Geol. Survey Bull. 340, pp. 257–262, 1908. 30c.

Hallet, A. F., The milling of vanadium ore: Colorado School of Mines Mag., vol. 5, No. 7, pp. 131–133, 1915.

Describes the process used in extracting vanadium from the roscoelite-bearing sandstone at Vanadium (formerly known as Newmire), Colo.

Hess, F. L., Notes on the vanadium deposits near Placerville, Colo.: U. S. Geol. Survey Bull. 530, pp. 142–156, 1913.

HESS, F. L., Vanadium in the Sierra de los Caballos, New Mexico: U. S. Geol. Survey Bull. 530, pp. 157–160, 1913.

——— Carnotite near Green River, Utah: U. S. Geol. Survey Bull. 530, pp. 161–164, 1913.

——— A hypothesis for the origin of the carnotites of Colorado and Utah: Econ. Geol., vol. 9, pp. 675–688, 1914.

——— Uranium and vanadium: U. S. Geol. Survey Mineral Resources, 1912, pp. 1003–1036, 1913. 90c.

A much fuller description of the radium, uranium, and vanadium resources of the United States than is contained in the present volume.

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MOORE, R. B., and KITHIL, K. L., A preliminary report on uranium, radium, and vanadium: U. S. Bureau of Mines Bull. 70, 100 pp., 1913.

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ANTIMONY.

By Frank L. Hess.

PRODUCTION.

Antimony prices in 1915 were probably the highest known since the metal became a regular article of commerce. The high prices led to the largest production the United States has made and probably to the largest world's production.

According to figures collected by the United States Geological Survey the production of antimony ores in the United States in 1915 is estimated at 5,000 tons, containing 2,100 tons of antimony, valued at about $425,000. The largest previous domestic production was in 1892, when 150 tons of metal was produced in San Francisco from Nevada ores and 380 tons of ore carrying 55 per cent of antimony was exported. Practically all operations of 1915 were new; most of them were small; and they were so widely scattered that it has been difficult to obtain accurate figures.

In Alaska, according to data collected by Alfred H. Brooks, about 735 tons of stibnite ore carrying 58 per cent antimony was produced in the Fairbanks district from properties on Eva, Vault, Treasure, and Chatham creeks. It is reported that 148 tons was shipped from Nome.

The largest output was made from deposits near Wild Rose Spring, on the northwestern slope of Telescope Peak, in the Panamint Range, Cal. These deposits have been known for many years but have been too isolated for profitable exploitation until 1915, when prices were high and a branch railroad was built to Trona, on Borax Lake, within about 25 miles of them. The deposits contain considerable antimony ocher as well as stibnite and were mined by the Western Metals Co. The same company operated deposits 30 miles northeast of Mojave that are 10 miles from the Southern Pacific Railroad, at Neuralia, in Kern County. Other deposits were mined in California at many points in Kern County, in the east end of San Benito County, and on Moores Flat, near Grass Valley, in Nevada County.

In Nevada considerable quantities were mined at many points, mostly in the northwest quarter of the State with Lovelock as a center, but ranging from Pass Canyon, in the Pine Forest Range, southward to the vicinity of Tonopah and eastward to Joy.

Oregon, Washington, and Idaho produced small quantities of ore, and in Arkansas a company was organized to work old properties west of Gilham.

In Utah a small quantity of stibnite was shipped from the deposits near Coyoto. These have been operated occasionally for many

years but are so far from a railroad—the nearest point is Marysvale—that they can be worked profitably only when prices are high.

Four smelting plants were operated during 1915 on antimony ores alone. The Chapman Smelting Co., of San Francisco, which had been idle for a number of years, again started the smelting of antimony ores. The company mined ore at Bernice, 60 miles east of Fallon, Nev., and bought ores at other points in the Western States, Alaska, and British Columbia. The Western Metals Co. built an antimony smelter at Industrial Harbor, Los Angeles. The company operated mines in both California and Nevada and also bought ores in the Western States, Alaska, and foreign countries. The Antimony Smelting & Refining Co., of Seattle, started a plant at Van Asselt, Wash., late in 1915, and made oxide, but metal is to be smelted also. The Magnolia Metals Co. found so much difficulty in obtaining needed supplies of antimony at a reasonable price that it bought and mined ores in Nevada, smelting them and foreign ores at Matawan, N. J. The plant was burned, but a better plant was erected. Besides these the International Smelting Co. bought ores to be smelted with lead ores at its South Chicago plant. The Great Western Smelting & Refining Co., of Chicago, and the Pennsylvania Smelting Co., of Pittsburgh, Pa., also smelted some ores with lead ores. The Harshaw, Fuller & Goodwin Co., of Cleveland, Ohio, was in the market for pure ores from which to make antimony salts, heretofore made from Chinese "crude antimony."

Besides the production of 2,100 tons of antimony in ores already noted, antimonial lead of domestic origin contained 2,800 tons of antimony, valued at $1,652,000—a total of 4,900 tons, valued at approximately $2,100,000, of which, however, the quantity of antimony actually recovered from the ores is unknown. The value of the antimony in the ore is the ore value; that in the antimonial lead is the value of the smelted product. As most antimonial lead is obtained as a by-product of the smelting of precious metals, it is impossible to give its ore value, which is in general really nothing, as it is not often considered in buying ores of precious metals.

Antimony ores can not be worked profitably at the usual prices under the high cost of labor in the mining regions of the United States except where the deposits are very large and advantageously situated, and unless some of those recently exploited prove better than those known before no deposits have been found that fulfill these conditions. As a result, practically all the antimony metal used here in other years has been imported from European, Chinese, and Japanese smelters. Most of the ores for these smelters come from China, Mexico, and France, though smaller quantities are obtained from Japan, Austria, and other countries.

The very high prices for antimony prevailing during the European war will probably last little longer than the war unless kept up by artificial measures, and except for such artificial barriers the country will probably go back to foreign sources for most of its metal.

For several years before 1915 the production of antimony in the United States from domestic ores had been confined to that contained in antimonial lead and the small quantities recovered in the electrolytic refining of copper and lead. A small quantity of antimony, determinable only by estimate, is produced from foreign ores. The domestic production since 1910 is shown below.

Antimony produced in the United States, 1910–1915.

Year.	Contained in antimonial lead of domestic origin.[a]		Contained in antimonial lead of foreign origin, but smelted in the United States.[a]		Average percentage of antimony in antimonial lead.	Recovered from old alloys, scrap, and dross.[b]	
	Quantity (short tons)	Value.	Quantity (short tons).	Value.		Quantity (short tons).	Value.
1910	1,598	[c] $263,431	631	[c] $103,906	15.85	2,779	[c] $457,979
1911	1,543	[d] 264,780	711	[d] 122,006	16.01	2,369	[d] 406,520
1912	1,224	[e] 209,059	725	[e] 123,830	14.38	2,506	[e] 428,025
1913	2,204	[f] 375,562	304	[f] 53,801	15.05	2,705	[f] 460,932
1914	2,530	[g] 529,740	175	[g] 36,750	16.16	2,646	444,844
1915	[h] 4,900	[i] 2,100,000	464	[i] 273,760	15.28	3,102	[i] 1,830,180

[a] Statistics collected by C. E. Siebenthal, United States Geological Survey.
[b] Statistics collected by J. P. Dunlop, United States Geological Survey. In 1910 a total of 9 tons; in 1911, 10 tons; in 1912, 13 tons; in 1913, 45 tons; and in 1914, 1 ton was recovered as antimony, the remainder as alloy.
[c] Estimated at 8.24 cents a pound.
[d] Estimated at 8.58 cents a pound.
[e] Estimated at 8.51 cents a pound.
[f] Estimated at 8.52 cents a pound.
[g] Estimated at 10.5 cents a pound. Includes actual marketed value of a few tons of antimony made as a by-product in the electrolytic refining of copper.
[h] The antimony in antimonial lead includes 2,100 tons of antimony in ore of domestic production.
[i] Estimated at 29.5 cents a pound.

IMPORTS.

The following table shows the countries from which the antimony was shipped to the United States. These are not invariably the countries of origin, but are merely those from which the materials were billed. Thus the ore credited to England and Panama was probably all from other countries, and this may be true for some of the ores from other ports. (See note under China, Hongkong, and Japan.)

Antimony imported into the United States in 1915.

Country.	Antimony ore.			Matte, regulus, or metal.	
	Quantity (short tons).	Antimony content (pounds).	Value.	Quantity (pounds).	Value.
Australia				800	$39
Brazil	1	1,690	$350	12,778	2,857
British India				23,750	7,010
Canada	10	10,355	1,911	63,480	15,791
Chile	664	948,647	90,834		
China [a]	1,341	1,863,090	206,461	8,282,943	1,753,397
Hongkong [a]				275,417	62,034
Japan [a]				7,995,888	1,647,472
England				559,668	112,722
France				23,150	3,682
Honduras	2	3,000	302		
Panama	14	20,051	973		
Mexico	520	338,543	23,340		
Peru	78	111,331	8,043		
Portugal	50	77,305	19,326		
Spain				246,156	28,416
	2,680	3,374,012	351,540	17,484,030	3,633,420

[a] Nearly all the imports of antimony ore, matte (liquated stibnite, known as "crude antimony" or "needle antimony"), and metal from Hongkong and Japan are of Chinese origin. Some of the material credited to other countries is possibly also of Chinese origin, having been transshipped in a foreign port.

For years large quantities of antimonial lead were imported into the United States as type metal, for which it is largely used. During 1912, 1913, 1914, and 1915 these imports have been much smaller, but

the imports for 1915 were nearly double those of 1914. The following table is compiled from the records of the Bureau of Foreign and Domestic Commerce:

Type metal imported and entered for consumption, 1906–1915.

Year.	Type metal.		Antimony content.	
	Quantity (short tons).	Value.	Quantity (short tons).	Percentage.
1906	9,801	$900,608	1,853	18.9
1907	7,416	932,027	1,369	18.5
1908	2,055	156,847	422	20.5
1909	6,997	532,108	1,327	19.0
1910	6,697	485,493	1,109	16.6
1911	4,195	310,658	727	17.3
1912	291	18,668	52	17.2
1913	284	20,098	50	17.6
1914	755	45,373	94	12.4
1915	1,384	107,607	172	12.4

The customs returns give only the lead content of imported type metal, and the figures given above are based on the assumption that the remainder is practically all antimony, but this assumption is wholly arbitrary, for imported type metal contains as much as 2 per cent of impurities, such as iron, arsenic, and copper. The antimony content is therefore probably too large by some quantity less than or approximately equal to 2 per cent of the total quantity of type metal, and the correct percentage is correspondingly lower.

China is the chief antimony-producing country, and from it the United States buys the larger part of its imported ore. The distribution, mining, and smelting of antimony in China are briefly described in the following excerpts from Commerce Reports, issued by the Bureau of Foreign and Domestic Commerce, Department of Commerce:

The antimony deposits of China are located south of the Yangtze River, in the provinces of Hunan, Kwangsi, Kwangtung, Yunnan, and Kweichow. The antimony district which produces the purest ores is in Hunan Province, and lies between the Siang and the Yuen rivers. The ores from this area carry from 20 to 64 per cent antimony and are practically free from arsenic. The Hunan mines are said to be the most important yet discovered in China.

The methods used in the mining of this ore in China have been, until recent years, primitive in the extreme. Previous to 1897 only antimony ore had been exported, but in that year the Tai Shing Mines Co. was formed and undertook to convert the ore into crude antimony. The success of this pioneer venture brought many mining enterprises into existence, and in 1912 eight smelting plants and more than 100 mining companies were in operation.[1]

[In 1915] exports of antimony regulus increased more than 100 per cent above the amount exported in 1914, the highest record previously reached in this metal. A corresponding increase is found in the export of antimony ash or refuse, which is being exported in large quantities to smelters at Hankow and elsewhere for the manufacture of antimony oxide and for the extraction of the fairly large percentage of antimony residue left by the crude refining methods practiced in the past.

The smelting of antimony has been a thriving business throughout the province and has been carried on with primitive methods. The result was

[1] Sammons, Thomas (consul general at Shanghai, China), Commerce Repts. Suppl. No. 52d, p. 14, 1916.

that large heaps of refuse and ash had been left by the smelters scattered up and down the interior of the province. It did not pay to work the ash until the rise in the value of antimony, due to increased demands brought on by the war, sent dealers and brokers in search of these ash heaps.[1]

A few years ago antimony was a cheap metal, but the European war has made antimony mining one of the most profitable mineral undertakings. The ore is not a product of this consular district, but comes chiefly from Hunan, although Hankow is the active center for its sale and shipment. The exports in 1915 included 21,326,600 pounds of crude antimony, valued at $816,879; 4,310,000 pounds of antimony regulus, valued at $554,716; 455,333 pounds of antimony ore, valued at $5,880; 672,000 pounds of antimony ore refuse, valued at $2,111; 523,467 pounds of antimony oxide, valued at $3,162; and 2,240,000 pounds of antimony oxide refuse, valued at $3,871, a total shipment of 29,528,400 pounds, as against 25,661,867 pounds exported in 1914.

In January, 1915, the price of antimony regulus, export duty paid, was 440 to 455 Hankow taels (about $245 to $247 United States currency) per net long ton. Crude antimony sold during that month at 220 to 240 taels ($122 to $133) per ton. There was no drop in price during the year, and in December crude sold for 530 to 620 taels ($294 to $344) per ton and regulus at 1,100 to 1,250 taels ($611 to $694).

Five smelting plants were operated in the vicinity of Hankow during 1915; three of these produced antimony regulus from antimony refuse, and two plants produced regulus from oxide ores. Both the antimony refuse and oxide ores consumed in these plants were imported from Hunan Province. No antimony ores were exported in 1915, except in small lots, which were probably to meet contracts antedating the war. Most of the regulus and crude antimony was shipped to Japan and the United States, although not consigned directly from Hankow to America, except in small quantities.[2]

The antimony for the most part is mined in a crude way and consequently the output is limited. The method of mining is, ordinarily, to dig manholes in the mountain side and extract ore therefrom until the tunnels reach a level where water or lack of ventilation renders further operation impracticable. When either of these conditions obtain the shafts are abandoned and fresh ones started. The Wah Chang Co. owns one or two mines, however, that are operated on more scientific lines.

The first smelters for the reduction of antimony, so far as is known, were established in 1907, when the Tai Shing Mining Co. was organized for the production of crude antimony. Following the successful operation of this company others were formed until in 1912 eight smelting works were actively engaged in reducing ore and more than 100 companies were mining, both for export and domestic consumption.

In 1908 the Kiu Tung Mining Co. was absorbed by a new organization known as the Wah Chang Mining & Smelting Co., which has a capital of approximately $180,000. It is subsidized by the Chinese Government and was granted a monopoly for a term of 10 years.[3]

Japan mines an insignificant quantity of ore but smelts a large quantity of Chinese ore, and the United States imports a considerable quantity of the metal from Japan.

During 1915 Bolivia[4] exported 7,191 tons of antimony ores (stibnite), part of which came to the United States. Many of the ores contained copper and other metallic impurities.

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[1] Johnson, N. T. (consul at Changsha, Changsha), Commerce Repts. Suppl. No. 52f, p. 29, 1916.

[2] Cunningham, E. S. (consul general at Hankow, Hankow), Commerce Repts. Suppl. No. 52g, p. 18, 1916.

"Crude antimony" is an awkward and misleading term meaning "liquated stibnite." It is also known as "needle antimony," and matte. It is made by melting the stibnite and allowing it to run away from the gangue. In cooling it forms long needlelike crystals, whence the name "needle antimony."

"Regulus" is a term which has been handed down from the alchemists and should be allowed to become obsolete. As now used it merely means "metal," so that "antimony," "regulus" and "refined antimony," which from year to year are noted in the reports of various governments, are redundants.

[3] Shannon, Thomas (consul general), Commerce Repts., Apr. 25, 1916, p. 325.

[4] Montavon, W. F. (commercial attaché), Exports of wolfram and antimony from Bolivia: Commerce Repts., Aug. 7, 1916, p. 485.

PRICES.

The price of antimony, which prior to July, 1914, had been at a monthly average of 7.11 cents a pound for Cookson's and 5.44 cents or more for other brands, rose gradually though unsteadily from that time to the end of 1915, when Chinese, Japanese, and American antimony was quoted at about 40 cents a pound.

Quotations for Cookson's antimony ceased in May, 1915, some time after an embargo had been declared against the shipment of antimony metal or ores from the British possessions and 50 cents a pound is said to have been paid for it about June 1, when Chinese antimony was selling for about 35 cents or less. In the fall of 1915 American antimony appeared on the market for the first time in many years. At first it sold slightly below Chinese and Japanese, but was soon quoted at the same price. Miners and smelters, apparently thinking that the high prices would be temporary, did not begin production very quickly.

Prices for ores ranged from $1 to $2.10 per unit of antimony. At first only ores carrying 50 per cent or more antimony were in demand, but before the close of the year 20 per cent ores were being shipped from Nevada.

The monthly average prices of various grades of antimony on the New York market in 1915 as compiled by The American Metal Market and Daily Iron and Steel Report [1] are shown below.

Monthly average prices (cents a pound) of antimony in New York, 1915.

Month.	Cookson's.	Hallett's.	Chinese and Japanese.
January	17.56	16.44	15.24
February	20.43	19.25	17.62½
March	27.84	24.12	20.93¾
April	32.07	29.41	23.97
May			34.71
June			36.53½
July			35.98
August			32.57
September			28.50
October			30.96
November			37.88
December			39.36½
Average for 1915			29.52

USES.

Antimony is used chiefly as an alloy with lead, to which it gives hardness. It also prevents contraction of the lead on solidification from a molten condition and may even make it expand slightly. The larger part of the alloy commonly known as antimonial lead is used alone or mixed with other metals for making "bearing metals." A very large proportion of power-driven machinery has its bearings coated or lined with friction-reducing compounds, most of them alloys of which antimonial lead forms a basis, except in very heavy machinery, where bronzes of various types are used.

Type metals all contain antimony in varying proportions up to 20 per cent. Antimony hardens the alloy and causes a perfect filling of the mold. Coffin handles and trimmings, badges, seals, the ground-

[1] Metal statistics, 1916, pp. 309–313.

work of a large part of silver-plated ware (except knives, forks, and spoons), metal toys, plated clock cases, and plated metal ornaments take great quantities of antimony.

Patents have been taken out by Francis C. Frary and Sterling W. Temple[1] for the use of calcium, magnesium, strontium, and barium as substitutes for antimony in alloys, though in some of these new alloys a small percentage of antimony is used and in all a small percentage of copper is found to be also of advantage.

Since the beginning of the European war great quantities of antimonial lead have been used in making shrapnel bullets. Lead is needed to give the proper weight, and antimony is required to harden the lead so that the bullets will not lose their shape when the shell explodes.

Antimony sulphide has also been used in some quantity in shells. Upon the explosion of the shell the stibnite burns and gives a white cloud of oxide. The light by night and the cloud by day show the point of explosion to the gunners and observers. Magnesium is used for the same purpose and is probably better, as the light is more intense and the cloud of oxide more dense. Artificial antimony oxide, sulphides, and other compounds are used in small quantity for paints and pigments, and in vulcanizing and filling rubber. Some antimony compounds are used in dyeing and some have been used in medicine, but very little is now so used. Antimony as pure metal has no known use.

TESTS FOR ANTIMONY MINERALS.

The antimony oxides are usually white or yellowish stony-looking minerals, perhaps more commonly than not having the general form of the sulphide from which they are formed. The sulphide, stibnite (Sb_2S_3), has a gray metallic luster and an excellent cleavage always noticeable in glistening faces, even in specimens where the faces are less than a millimeter (one-twenty-fifth of an inch) across. All the antimony minerals are comparatively soft, and stibnite may be scratched with the finger nail.

Before the blowpipe stibnite melts immediately and volatilizes, giving thick fumes of white oxide which have a fetid odor (not noticeable to some persons and pronounced odorless by textbooks) and which condense on the charcoal or plaster of Paris near the assay and are easily revolatilized and driven about by the blowpipe. Some antimony oxides are not volatile in the oxidizing flame, but may be reduced to metal and then be volatilized by treating with the reducing flame. If sulphur is added to the oxides they give the same effect as the native sulphide. Small fragments of stibnite are easily melted in the flame of a candle or a match.

If bismuth flux (equal parts of sulphur and potassium iodide) is added to an antimony mineral and both are heated before the blowpipe flame an orange coating, yellow near the assay, is deposited on either charcoal or plaster of Paris, but is much more noticeable on the latter. The color disappears on exposure to strong ammonia fumes.

PUBLICATIONS.

Some publications on antimony are included in the list on page 850.

[1] U. S. patents 1158671, 1158672, 1158673, 1158674, and 1158675, dated Nov. 2, 1915.

ARSENIC.[1]

By Frank L. Hess.

PRODUCTION.

The output of arsenic in the United States in 1915 was much the largest yet made in this country and amounted to 5,498 short tons, valued at $302,116, an increase of nearly 18 per cent over the production of 4,670 tons, valued at $313,147, in 1914, and an increase of about 75 per cent over the largest previous production, that of 1912, when 3,141 tons, valued at $190,757, were produced.

As usual, the arsenic was all saved as a by-product in the smelting of copper and gold and silver ores.

White arsenic was not produced in the United States until 1901, when the Puget Sound Reduction Co., at Everett, Wash., made an output of 300 short tons, saved as a by-product in smelting gold and silver ores. The production to date is shown below:

White arsenic (As_2O_3) produced in the United States, 1901–1914.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1901	300	$18,000	1909	1,214	$52,946
1902	1,353	81,180	1910	1,497	52,305
1903	611	36,691	1911	3,132	73,408
1904	36	2,185	1912	3,141	190,757
1905	754	35,210	1913	2,513	159,236
1906	737	63,460	1914	[b] 4,670	313,147
1907	1,751	163,000	1915	[c] 5,498	302,116
1908	(a)	(a)			

[a] Only two firms produced arsenic in the United States in 1908, so that the figures can not be published without disclosing confidential returns.
[b] This quantity includes 200 tons of crude arsenic trioxide carrying about 97.5 per cent As_2O_3.
[c] This quantity includes 353 tons of crude arsenic trioxide carrying about 97.5 per cent As_2O_3.

The refined arsenic produced is reported to be above 99.5 per cent As_2O_3.

IMPORTS.

The imports of arsenic compounds are large, though they have declined since 1913. The figures showing the imports for consumption by calendar years since 1909, as reported by the Bureau of Foreign and Domestic Commerce, are given in the table below; before 1909 the returns were given only for fiscal years ending June 30.

[1] An extended article on arsenic was published in U. S. Geol. Survey Mineral Resources, 1914, pt. 1, pp. 953–964, 1916.

Arsenic compounds imported for consumption in the United States, 1909–1915.

Year.	Arsenic or arsenious acid (white arsenic, As_2O_3).		Arsenic and sulphide of, or orpiment.		Sheep dip.		Paris green and London purple.	
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
1909	445	$31,235	3,591	$272,493	1,574	$9,615	183,765	$20,370
1910	1,348	76,282	3,791	238,024	.....	24,279	181,363	14,648
1911	1,921	116,948	2,175	127,375	.....	20,642	126,191	4,972
1912	3,103	200,616	3,053	228,125	.....	41,556	162,272	6,950
1913	1,519	133,597	3,182	276,849	.....	40,036	99,692	4,431
1914	1,594	109,121	2,034	164,592	.....	34,556	15,476	2,235
1915	1,400	113,677	1,783	154,099	.....	19,916	21,056	4,069

PRICES.

Prices of white arsenic averaged from 2.45 to 2.83 cents a pound at the works. The prices in New York, according to the Oil, Paint, and Drug Reporter, were very steady, starting at 4 to 4.5 cents a pound in January, declining to 3.5 to 4 cents in August, and closing in December at 3.875 to 4.5 cents a pound. Lead arsenate was quoted at 5.5 to 6 cents a pound until November, when it rose to 6.5 to 7 cents a pound. Red arsenic (AsS) was quoted at 8 cents a pound at the beginning of the year, rising to 8.25 to 9 cents in November. No quotations were given in December.

FIELD TESTS FOR ARSENIC.

When arsenopyrite is struck with a hammer it gives off an odor somewhat like garlic—the "alliaceous odor" of the textbooks—an odor familiar in mines where drills are cutting rock or ore impregnated with arsenopyrite. If arsenopyrite, enargite, cobaltite, smaltite, safflorite, niccolite, or similar arsenical minerals are heated in the air they give off the same odor much more freely. The sulphur-bearing arsenic minerals give off first the familiar odor of sulphur dioxide, then the garliclike odor. If heated in a closed tube the arsenides give a yellow ring, probably of arsenic sulphide, and nearer the assay a ring of dark, silvery elemental arsenic so dense that it gives a mirror effect. This is the "arsenic mirror" and it shows beautifully the metallic luster of the element.

Enargite gives a ring of yellow arsenic sulphide but no mirror. A nickel-arsenic antimony sulphide, possibly to be classed as arite, gives in the closed tube, toward the cool end, a yellow arsenic sulphide ring, nearer the assay an arsenic mirror, and nearest the assay a dull-red ring, which is probably antimony sulphide.

PUBLICATIONS.

Publications on arsenic are included in the list on page 850.

BISMUTH.

By Frank L. Hess.

PRODUCTION.

The only bismuth known to have been produced in the United States during 1915 was that isolated as a by-product by the American Smelting & Refining Co., at Omaha, and by the United States Metals Refining Co., at Grasselli, Ind. Both companies refine lead bullion electrolytically and save the bismuth from the anode muds.

The American Smelting & Refining Co. obtains a considerable quantity of bismuth in flue dusts saved by the Cottrell process at its Garfield (Utah) plant and from lead bullion from Leadville, Colo. It is said that at Leadville a special furnace is run at times upon ores carrying bismuth, in order that the bismuth may be collected in comparatively concentrated form. Both flue dusts and bullion are shipped to Omaha for treatment.

The United States Metals Refining Co.'s bismuth-bearing lead comes largely from Tintic, Utah.

Only one lot of bismuth ore is known to have been sold as such during 1915. Wilson Bros. sold a small parcel from the Clifton district, Deep Creek Mountains, Tooele County, Utah.

IMPORTS.

Metallic bismuth imported for consumption in the United States, 1906–1915.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1906	254,733	$318,452	1911	172,093	$311,771
1907	259,881	325,015	1912	182,840	316,440
1908	164,793	257,397	1913	117,747	213,257
1909	183,413	286,516	1914	90,505	165,208
1910	198,174	332,668	1915	44,362	108,288

It will be seen that the imports of bismuth have dwindled almost steadily since 1910, but the reduction in 1915 was undoubtedly much more than normal and was caused by the European war. The production in this country is in the hands of companies which are so strong and whose bismuth resources are so certain that the usual tactics said to have been formerly employed by the foreign companies in whose control most of the world's bismuth trade is held—cutting off future supplies from those who have dealt with a competitor—are not now so often reported.

PRICES.

As quoted by the Engineering and Mining Journal (New York), the price of bismuth during the year was from $2.75 to $3 a pound.

USES.

Bismuth is not a widely useful metal. Its brittleness prevents its use in any alloy that should be tough or malleable. It expands on solidifying from the molten condition, and on account of this property it has sometimes been used in type metal. It is used chiefly in medicine, for which it furnishes a considerable number of salts. Bismuth salts are used in dressing wounds, and it is said that large quantities are being so used in the war hospitals of Europe, and this may in part account for the large decrease in imports in 1915. Bismuth nitrate is sometimes given internally when roentgenographs of the abdominal region are to be made, as bismuth salts are opaque to the Roentgen (X) rays. Bismuth is extensively used in alloys of low melting point or cliché alloys, such as are required for the automatic sprinklers placed as a protection against fire in warehouses and stores, in fuses for electric wiring, and in solders. Its use in storage batteries is said to be prevented by its high price. Its salts have been used in face powders, as their smoothness is very grateful, but they are said to darken in atmospheres containing sulphur, so that this use is largely discontinued. A little bismuth is used in some bearing metals.

TESTS FOR BISMUTH MINERALS.

If bismuth minerals are mixed with twice their bulk of a flux containing equal parts of sulphur and potassium iodide (KI) and heated before a small oxidizing blowpipe flame on either a plaster of Paris plate or charcoal, a coating is obtained that is yellow near the assay and a fine red farther away. This is characteristic. The test is credited to Von Kobell.

If ordinary tincture of iodine is added to a bismuth mineral and the mixture is heated on a plaster of Paris plate before a blowpipe with a small oxidizing flame, it gives a chocolate-brown coating of bismuth iodide which is changed to a brilliant red by exposure for a short time to strong ammonia fumes.[1] The red is the same in both tests.

If bismuth or a bismuth mineral or compound is dissolved in concentrated nitric or hydrochloric acid, a clear liquid results; but if it is largely diluted the bismuth salt becomes hydrolyzed and gives a white cloudy precipitate. A good way to perform this test is to dissolve the substance in a small quantity, say a teaspoonful (4 or 5 cubic centimeters) of acid in a test tube or tumbler and then pour this into a tumbler full of water. The presence of common salt in the solution or water will prevent the precipitation of the bismuth.

[1] Brush, J., Manual of determinative mineralogy, with an introduction on blowpipe analysis, revised by S. L. Penfield, 15th ed., p. 55, 1899.

SELENIUM AND TELLURIUM.[1]

By Frank L. Hess.

No new uses and no new developments in the selenium industry came to light during 1915. The quantity produced was smaller than in the two preceding years and was made by only two companies, so that the figures may not be given. As usual, the selenium was obtained as a by-product in the electrolytic refining of copper.

No tellurium is known to have been produced.

Field tests for selenium.—When selenium minerals are heated on charcoal before the blowpipe, they give off a peculiar fetid odor, very much like that of carbon disulphide, an odor spoken of in textbooks as that of "rotten horseradish"—an unknown smell to most persons. If the selenium is sufficient in quantity it forms red fumes, a part of which is deposited on the charcoal as a deep-red coating and a part is changed to selenium dioxide (SeO_2) and deposited as a silvery-white coating. If the blowpipe flame is turned upon the red coating it burns with a characteristic sky-blue flame. Heated in a closed tube selenide minerals form a red coating above the assay and may form a coating of white oxide. They emit the characteristic odor.

Field tests for tellurium.—Brush and Penfield[2] give the following fairly satisfactory field tests for tellurium:

> A very delicate test for tellurium or tellurides may be made by heating a little of the finely powdered mineral in a test tube with about 5 cubic centimeters of concentrated sulphuric acid, when the latter assumes a beautiful reddish-violet color. After cooling, addition of water will cause the color to disappear, and a grayish-black precipitate of tellurium will be thrown down.
>
> Another test, applicable to all compounds containing tellurium, is to heat a mixture of the finely powdered substance with sodium carbonate and a little charcoal dust in a rather large closed glass tube, by which means sodium telluride is formed, and after cooling and addition of water the solution will assume a reddish-violet color. If a few drops of the solution are transferred to a porcelain plate or watch glass by means of a pipette, the color soon disappears, and a gray precipitate of tellurium forms, owing to the oxidizing action of the air. The color disappears more quickly if air is blown through some of the solution.
>
> By heating in the open tube, tellurium and the tellurides are oxidized and yield TeO_2, which passes up the tube as a white smoke, but mostly condenses near the heated part as a white sublimate. On heating the latter, it volatilizes very slowly and fuses into globules, which are yellow when hot, and white or colorless when cold.
>
> Heated in the closed tube, tellurium volatilizes and condenses on the hot glass as fused globules having a metallic luster. Accompanying the tellurium are white or colorless globules of the oxide, TeO_2, formed from the oxidation, due to the air in the tube.

[1] Selenium and tellurium were discussed at some length in U. S. Geol. Survey Mineral Resources, 1914, pt. 1, pp. 969–977, 1916.

[2] Brush, G. J., Manual of determinative mineralogy, with an introduction on blowpipe analysis, revised by S. L. Penfield, 15th ed., pp. 124–125, 1899.

Heated before the blowpipe on charcoal, tellurium is volatilized and condenses near the heated part as a white sublimate of TeO_2, somewhat resembling antimony oxide. Some tellurium may escape oxidation and condense as a slight brownish coating distant from the assay. The sublimates volatilize when heated before the blowpipe and impart a pale-greenish color to the reducing flame.

PUBLICATIONS.

The following publications relate to the antimony, arsenic, bismuth, selenium, and tellurium deposits of the United States. The Survey publications, except those to which a price is affixed, may be obtained free by applying to the Director, United States Geological Survey, Washington, D. C. The priced publications may be purchased from the Superintendent of Documents, Washington, D. C. The other publications may be consulted at the larger libraries of the country.

BLAKE, W. P., Antimony: U. S. Geol. Survey Mineral Resources, 1883–84, pp. 641–653, 1885. 60c.

——— Arsenic: Idem, pp. 656–657. 60c.

——— Bismuth: Idem, pp. 654–655. 60c.

BROOKS, A. H., Antimony deposits of Alaska: U. S. Geol. Survey Bull. 649, 67 pp., 1916.

HESS, F. L., The Arkansas antimony deposits: U. S. Geol. Survey Bull. 340, pp. 241–252, 1908. 30c.

——— The arsenic deposits at Brinton, Va.: U. S. Geol. Survey Bull. 470, pp. 205–211, 1911.

——— Antimony: U. S. Geol. Survey Mineral Resources, 1914, pp. 947–952, 1916.

——— Arsenic: Idem, pp. 953–964.

——— Bismuth: Idem, pp. 965–968.

——— Selenium: Idem, pp. 969–974.

——— Tellurium: Idem, pp. 975–977.

MALLERY, WILLARD, Antimony veins at Bernice, Nev.: Min. and Sci. Press, vol. 112, p. 556, 1916.

PALMER, L. A., Arsenic manufacture at Midvale [Utah]: Mines and Minerals, vol. 30, pp. 641–644, 1910.

RICHARDSON, G. B., Antimony in southern Utah: U. S. Geol. Survey Bull. 340, pp. 253–256, 1908. 30c.

WANG, C. Y., Antimony: Its history, chemistry, mineralogy, geology, metallurgy, uses, preparations, analysis, production, and valuation; with complete bibliographies, Philadelphia, J. B. Lippincott Co., 217 pp. 1909.

ZINC.

(GENERAL REPORT.)

By C. E. Siebenthal.

SUMMARY.

Spelter produced and consumed in the United States, 1910–1915, in short tons.

	1910	1911	1912	1913	1914	1915
Production of primary spelter: [a]						
From domestic ore	252,479	271,621	323,907	337,252	343,418	458,135
From foreign ore	16,705	14,905	14,899	9,424	9,631	31,384
	269,184	286,526	338,806	346,676	353,049	489,519
Production of secondary spelter: [a]						
Redistilled	12,784	14,043	26,064	25,991	20,545	29,764
Remelted	28,439	26,470	26,187	24,014	22,424	23,136
	310,407	327,039	391,057	396,681	396,018	542,419
Apparent consumption of primary spelter	245,884	280,059	340,341	295,370	299,125	364,494

[a] "Primary spelter," which is produced directly from ore, is here distinguished from "secondary spelter," which is obtained by refining zinc ashes, skimmings, drosses, and old metals. The statistics of secondary spelter are given on page 856. Wherever in this report the word "spelter" is used without qualification it means primary spelter.

The production of primary spelter from domestic ores in 1915 was 458,135 short tons, valued at $113,617,000, based on the average selling price, as compared with 343,418 short tons, valued at $35,029,000, based on the average St. Louis price, in 1914—an increase of 114,717 tons, about 33 per cent, in quantity and of $78,588,000, about 225 per cent, in value.

INTRODUCTION.

The preliminary estimate of the production of primary spelter in 1915 was given out in the form of a press bulletin on January 3, 1916. The advance statement, giving the final figures of production and consumption of spelter, was published April 4, 1916. The midyear statement of production and consumption of spelter, during the first six months of 1916, was published August 15, 1916. It gave a list of smelters brought up to date and of the new plants under construction and contemplated, several tables of exports of zinc and of manufacture of zinc by months, and showed the results of the stimulus of the war on the zinc industry of the United States by six-month periods. These tables are repeated on a later page.

The present report includes the figures given out in the advance statements, and contains, in addition, tables of imports and exports of spelter and of zinc ore, a comparison of mine and smelter returns, a list of zinc smelters, a short account of the advance in metallurgy

and ore dressing as applied to zinc ores, a brief review of the zinc resources of countries producing zinc in competition with the United States, and finally, a summary of the domestic and foreign conditions of the zinc industry, including a section on the especial effects of the war.

The statistics of production in this country have been compiled by the United States Geological Survey from confidential reports from each zinc-smelting company in operation during 1915. Statistics of the recovery of secondary zinc were collected from all the important secondary smelters and refiners. The statistics of domestic consumption are taken in part from the smelter returns and in part from the records of the Bureau of Foreign and Domestic Commerce of the Department of Commerce, and the tables for foreign production and consumption were compiled from the sources indicated.

This report includes a fairly comprehensive review of the zinc resources of each State producing zinc. The time required for this compilation has considerably delayed the publication of the chapter. As these reviews are only published at intervals of several years, advantage has been taken of the delay to include notes on developments during 1916.

PRODUCTION.

ANNUAL PRODUCTION 1873–1915.

The production of spelter in the United States began in 1858 in an experimental way,[1] and regular production began in 1860 at the Lehigh Zinc Works in the East and at the Matthiesson & Hegeler works in the West. Between 1864 and 1870 nine or ten other zinc smelters were established. Statistics of production are recorded for the years 1873 and 1875 and for the census year ending May 31, 1880. Annual statistics have been collected by the United States Geological Survey since 1882. The progress of the zinc-smelting industry since 1873 is shown in the following table:

Spelter produced in the United States from domestic and foreign ores, 1873–1915, in short tons.

Year.	From foreign ore.	From domestic ore.	Total.	Year.	From foreign ore.	From domestic ore.	Total.
1873	.....	7,343	7,343	1898	.....	115,399	115,399
1875	.....	15,853	15,853	1899	.....	129,051	129,051
1880 (census)	.....	23,239	23,239	1900	.....	123,886	123,886
1882	.....	33,765	33,765	1901	.....	140,822	140,822
1883	.....	36,872	36,872	1902	.....	156,927	156,927
1884	.....	38,544	38,544	1903	.....	159,219	159,219
1885	.....	40,688	40,688	1904	.....	[a] 186,702	186,702
1886	.....	42,641	42,641	1905	.....	[a] 203,849	203,849
1887	.....	50,340	50,340	1906	25,076	199,694	224,770
1888	.....	55,903	55,903	1907	26,115	223,745	249,860
1889	.....	58,860	58,860	1908	19,675	190,749	210,424
1890	.....	63,683	63,683	1909	25,535	230,225	255,760
1891	.....	80,873	80,873	1910	16,705	252,479	269,184
1892	.....	87,260	87,260	1911	14,905	271,621	286,526
1893	.....	78,832	78,832	1912	14,899	323,907	338,806
1894	.....	75,328	75,328	1913	9,424	337,252	346,676
1895	.....	89,686	89,686	1914	9,631	343,418	353,049
1896	.....	81,499	81,499	1915	31,384	458,135	489,519
1897	.....	99,980	99,980				

[a] Including an unknown quantity smelted from foreign ore, small in 1904, but larger in 1905.

[1] Ingalls, W. R., Lead and zinc in the United States, p. 314.

Spelter produced in the United States, 1906–1915, apportioned according to States in which smelted, in short tons.

Year.	Eastern and Southern States.	Illinois.	Missouri.	Kansas.	Oklahoma.	Colorado.	Total.
1906	29,930	47,939	11,077	129,564	.....	6,260	224,770
1907	37,626	56,056	11,732	134,108	5,035	5,303	249,860
1908	32,738	50,244	10,201	99,298	14,864	3,079	210,424
1909	42,941	67,653	7,037	103,299	28,782	6,048	255,760
1910	43,606	73,038	5,571	105,697	34,760	6,512	269,184
1911	47,155	83,130	4,116	98,443	46,315	7,397	286,526
1912	56,252	88,397	7,085	101,104	76,925	9,043	338,806
1913	69,063	106,654	5,085	74,106	83,214	8,554	346,676
1914	77,593	127,946	3,550	44,510	91,367	8,083	353,049
1915	103,409	159,958	6,754	101,423	109,208	8,767	489,519

Spelter produced in the United States, 1911–1916, by six-month periods, apportioned according to States in which smelted, in short tons.

	Illinois.	Kansas.	Oklahoma.	All other States.	Total.
1911:					
First half	41,255	50,574	19,997	28,370	140,196
Second half	41,875	47,839	26,318	30,298	146,330
1912:					
First half	44,224	52,485	36,010	33,777	166,496
Second half	44,173	48,619	40,915	38,603	172,310
1913:					
First half	53,524	42,645	43,253	40,791	180,213
Second half	53,130	31,461	39,961	41,911	166,463
1914:					
First half	62,062	23,737	45,443	43,816	175,058
Second half	65,884	20,773	45,924	45,410	177,991
1915:					
First half	74,982	35,247	51,172	55,131	216,532
Second half	84,976	66,176	58,036	63,799	272,987
1916:					
First half	90,082	74,592	73,298	78,480	316,452

ZINC DUST.

The early market for zinc dust was mainly western, the use being for zinc-dust precipitation in cyaniding in South Dakota, Nevada, and elsewhere. More recently the sherardizing process of galvanizing has created a market for zinc dust in the eastern part of the country. It has been discovered that in a drum from which the air has been exhausted articles may be sherardized in a much shorter time than at atmospheric pressure, the same effect being accomplished experimentally in 10 minutes that would require six hours in the ordinary way. The successful commercial application of this discovery and the development of a continuous method should greatly increase the field for sherardizing and likewise the market for zinc dust.

Zinc dust has been marketed by domestic smelters since 1910. The United States Zinc Co., at Pueblo, Colo., was the first to prepare it for the market; the Grasselli Chemical Co. followed later; and one by one other companies began to save zinc dust until in 1915 the companies named below reported production. Some of these companies saved zinc dust for the first time in 1914–15, being led thereto by the high price of zinc dust consequent upon the inability of Belgium and Germany to export any to the United States.

Zinc smelters that prepared zinc dust for market in 1915.

Clarksburg Zinc Co., Clarksburg, W. Va.
Grasselli Chemical Co., Clarksburg, W. Va.
Illinois Zinc Co., Peru, Ill.
Mineral Point Zinc Co., Depue, Ill.
National Zinc Co., Bartlesville, Okla.
New Jersey Zinc Co., Palmerton, Pa.
United States Zinc Co., Pueblo, Colo.

The following table gives the output of zinc dust since its first production in a commercial way in the United States:

Production of zinc dust in the United States, 1910–1915.

	Short tons.		Short tons.
1910	69	1913	423
1911	254	1914	1,004
1912	492	1915	1,755

As will be seen from the table of imports of zinc dust given on page 962, the quantity imported in 1915 fell off about two-thirds, corresponding to the increase in domestic production. The extremely high price of zinc dust lessened its use to some extent and the consumption was about 500 tons below the average for the last five years.

ZINC PIGMENTS.

There are four white pigments which have zinc for a base, either in whole or in part—zinc oxide, leaded zinc oxide, zinc-lead oxide, and lithopone. All of these may be, and in the United States the first three usually have been, made directly from ore.

Zinc oxide is the most important of these pigments. In European practice the oxide is made from spelter, though in France zinc oxide is made from ore in the electrothermic furnace invented by Côte and Pierron. In the United States the oxide is generally made from ore, but in 1915 the total production included also the oxide made from spelter—6,633 short tons, as compared with 7,626 short tons in 1914. The production of zinc oxide in 1911–1915 may not be disclosed. In 1910 it was 58,481 short tons, as compared with 68,974 tons in 1909 and with 57,237 tons in 1908. The imports of zinc oxide for consumption in 1915 were 882 short tons, and the exports for the same period were 19,980 short tons.

Leaded zinc oxide and zinc-lead oxide are produced from ore, both in the same plant at some places, the zinc-lead containing somewhat the larger percentage of lead. No zinc-lead oxide has been made since 1909. The production of leaded zinc pigment in 1911–1915 may not be disclosed, but in 1910 it was 6,823 short tons.

Lithopone is an intimate mixture by chemical precipitation of zinc sulphide and barium sulphate. It may be manufactured from ore, spelter, or zinc oxide, but in the United States is is generally made from zinc skimmings, zinc ashes, and scrap zinc. The production of lithopone is now ten times as large as it was 10 years ago as shown in the following table:

Production of lithopone in the United States, 1906–1915, in short tons.

	Short tons.		Short tons.
1906	4,300	1911	16,866
1907	10,275	1912	24,220
1908	8,292	1913	29,685
1909	14,847	1914	32,819
1910	12,655	1915	43,422

The zinc content of the various pigments made in the United States from ore, both domestic and foreign, for the period 1908–1915, is given in the table below. The figures as heretofore given for each year included the zinc content of zinc dust produced that year. The publication of the production of zinc dust in another table makes it possible to exclude the zinc dust from the quantities below, which leaves zinc in pigments only. On page 856 a portion of the secondary zinc recovered in the form of pigments is given:

Primary zinc content of zinc pigments made in the United States, 1908–1915.

	Short tons.		Short tons.
1908	48,004	1912	64,032
1909	54,139	1913	70,622
1910	50,592	1914	70,619
1911	46,122	1915	79,572

The Donora Zinc Co. is building a zinc-oxide works in connection with the zinc smelter at Donora, Pa. It will have a daily capacity of 10 tons of zinc oxide and will be completed by the end of 1916. Zinc ashes and ore will be treated.

The Western Zinc Oxide Co., which took over the works of the Western Zinc Mining & Reduction Co., at Leadville, is affiliated with the Midland Chemical Co., of Chicago, makers of lithopone, and the whole output of the works will be used in the manufacture of lithopone. The plant has been recently enlarged, giving it a treatment capacity of 75 tons of ore daily. A 50-ton roaster has been added so that sulphide ore may be used.

The Krebs Pigment & Chemical Co., completed, early in 1916, additions to the lithopone plant at Newport, Del., which increased the capacity to two and one-half times the former capacity.

The New Jersey Zinc Co. built a large lithopone plant at East Palmerton, Pa., near the zinc smelter.

The Midland Chemical Co., in 1915, completed a lithopone plant at Argo, a suburb of Chicago, Ill. This company is interested in the Western Zinc Oxide Co., as noted above.

The River Smelting & Refining Co. built an experimental plant at Florence, Colo., to treat complex ores, recovering zinc as zinc oxide, lead as oxide or basic lead sulphate, and other valuable metals in metallic form or as matte. The method used is thus a fire concentration process, the oxidized concentrates from which are treated in the electrolytic plant of the same company at Keokuk, Iowa.

Progress is being made in the recovery of zinc from retort residues. In the method devised by Archibald Jones [1] the residues, hot from the retorts, are heaped on a brick hearth beneath which pass flues connected with an ordinary blower. The unburnt coal in the residues is ignited and volatilizes the zinc, which is condensed in the outer layers of the heap as zinc oxide. This forms a crust which is broken off and charged back into the retorts.

The Mineral Point Zinc Co., at Depue, Ill., has for a year had a block of Wetherill furnaces in operation on retort residues, and has another block under construction. Several other companies, including the American Zinc & Chemical Co., are reported to be planning

[1] Eng. and Min. Jour., vol. 98, p. 961, 1914.

similar operations. Information is not at hand as to whether the zinc oxide recovered is suitable for pigment or whether it must be charged again into the retorts. In any event the plan must add materially to the zinc recovery.

SECONDARY ZINC.

In the ordinary method of galvanizing, where the material to be coated is dipped into a bath of molten zinc, there is a great loss of zinc in the form of semioxidized skimmings and of hard zinc drosses, caused by the alloy formed by the zinc with the iron of the tank and the iron of the article being galvanized. In the larger galvanizing plants there are furnaces to refine these skimmings and drosses and to recover the spelter. There are also many small plants and some large ones which make a practice of buying galvanizer's skimmings and drosses and of recovering the spelter. A considerable quantity of old metal in the form of various alloys of zinc with copper and other metals is also worked over and brought up to the desired composition by the addition of new metal. At almost every brass foundry and machine shop in the country it is the custom to remelt and use brass filings, grindings, and scrap copper and brass, and it is manifestly impracticable to attempt to take full account of such material. Some of the zinc smelters running on ore find it advantageous to work in a quantity of secondary material, because the loss of zinc in distillation is practically a fixed quantity per charge, whether the charge be of low or high tenor. If secondary material high in zinc is mixed with low-grade ore, the loss per unit of metal recovered is thereby greatly lessened. Where this is done the smelters make proper returns to the United States Geological Survey, and account has been taken of such protection in these reports prior to 1907 as dross or secondary spelter. As such spelter has been recovered by redistillation, it is practically indistinguishable in quality from spelter of ordinary grades made from ore. Several secondary smelters recovering zinc from drosses do so by redistillation, and these plants are included in the list of smelters on a later page. It has seemed advisable that the secondary spelter recovered by redistillation should be separated from that recovered by remelting, and it has accordingly been done in the table below. The canvass of secondary smelters was made by J. P. Dunlop, of the United States Geological Survey.

Secondary zinc produced in the United States, 1910–1915, in short tons.

	1910	1911	1912	1913	1914	1915
Secondary spelter, redistilled	12,784	14,043	26,064	25,991	20,545	29,764
Secondary spelter, remelted	28,439	26,470	26,187	24,014	22,424	23,136
Recovered zinc in alloys, excluding old brass remelted	2,709	3,223	3,912	3,743	3,914	5,300
Recovered zinc in remelted brass	18,450	24,110	28,426	25,822	24,759	34,375
Secondary zinc recovered as metal	62,382	67,846	84,589	79,570	71,642	92,575
Secondary zinc recovered in pigment	2,646	3,036	4,619	3,705	6,536	8,323
Secondary zinc recovered in zinc chloride[a]	3,970	3,865	4,903	6,253	6,429	7,860
Total secondary zinc	68,998	74,747	94,111	89,528	84,607	108,758

[a] These figures include only the quantity of zinc chloride used in wood preservation and were furnished by courtesy of the Forest Service, Department of Agriculture.

COMPARISON OF TOTALS, BASED ON SMELTER AND MINE REPORTS.

The figures of the production of spelter given in the foregoing pages are compiled from reports from individual zinc smelters. Since 1904 statistics of the production of the more valuable metals in the Western States have been obtained by the United States Geological Survey from reports of individual mines, and since 1907 this compilation has been extended over the whole country. In order to put the smelter production on the same basis as the mine figures, all the zinc which is manufactured into pigment directly from ore (excluding the quantity in zinc oxide manufactured from spelter, the inclusion of which would entail its duplication in the totals) is added to the production of metallic zinc. The zinc dust recovered during the year is also included here. The zinc recovered from secondary sources is excluded, since it has already been once reckoned as spelter. These facts must be borne in mind in comparing this table with the table showing the production of spelter. The totals obtained by each method for the last nine years are compared in the following table:

Comparison of production of domestic zinc by smelters and by mines, 1907–1915, in short tons.

	Totals compiled from smelter reports.	Totals compiled from mine reports.	Smelter excess.	Mine excess.
1907	280,676	259,951	20,725	
1908	238,030	234,526	3,504	
1909	283,173	305,423		22,250
1910	303,139	327,712		24,573
1911	315,029	345,260		30,231
1912	386,783	378,816	7,967	
1913	408,289	406,416	1,873	
1914	424,672	406,959	17,713	
1915	539,074	586,491		47,417
	3,178,865	3,251,554		72,689

The smelter totals represent actual recovery and are found by summing up the total production reported by all companies, all pigments and zinc dust being calculated back to equivalent metallic zinc on the basis of average analysis of product. In compiling the mine totals each producing property is requested to report actual quantity of zinc ores and concentrates shipped, and from this the zinc content is reckoned by assay value. From that zinc content 10 to 20 per cent, according to the character of the ore, is deducted for smelting losses, and the remainders thus obtained from all the producing properties in each State are combined to afford the totals for the respective States. Where the ore is concentrated at a custom mill, proper allowance is also made for the loss of metal in the process. It is clear that by either method the correctness of the totals is dependent upon complete and correct returns from each producing mine and smelter. It is further essential to the correctness of the mine totals that the assay content and the theoretical recovery be correctly estimated. The totals, as compiled from smelter reports

and from mine reports, respectively, should be in reasonable agreement. As a matter of fact, for any year they show considerable divergence. These discrepancies, giving rise to "smelter excess" or "mine excess," may be the result of one cause or of a combination of causes, among which are: Lag in the smelting of the ore, resulting in accumulation of ore stocks at the smelters; lag in the mining owing to which the smelter depletes its ore stocks; error in calculating metallic content from assay and in estimating recovery.

The recoverable zinc content of domestic zinc ore exported from this country since 1907, inclusive, should be added to the smelter totals to make the comparison complete. According to the figures of the Bureau of Foreign and Domestic Commerce the exports of domestic zinc ore from 1907 to 1915, inclusive, amounted to 149,911 short tons, of which the recoverable zinc content may be estimated at 62,962 tons. If this quantity be added to the smelter total, that total will still be less than the mine total, giving a mine excess of 9,727 tons, or three-tenths of 1 per cent.

Theoretically the smelter and mine totals taken for a considerable number of years as above should agree closely, as the mine totals express recoverable zinc content of ores, allowance having been made for smelting losses. Difference in smelter stocks of ore at the beginning of 1907 and the close of 1915 would cause a discrepancy in the totals. There was a big smelter excess in 1907 and a big mine excess in 1915, hence there were large stocks of ore at the beginning of 1907 and at the close of 1915. This would account for the mine excess, the unsmelted ore being in stock at smelters. The number of smelters has so greatly increased since 1914 that there is naturally a large increase in the quantity of ore in stocks.

The smelter reports give the exact annual production of zinc and serve as a check on the mine production, and they also give the form in which the zinc was recovered, whether as spelter or as pigment. For more exact distribution of zinc production according to origin, recourse must be had to the reports of production by mines.

RESOURCES.

GENERAL.

The war has for the time being eliminated certain sources of zinc supply and, through resulting high prices, has opened other sources. The main dependence of the world for zinc, outside of the Germanic allies, is, of course, the United States. But several other countries find in present conditions a stimulus to activity in production of zinc, among them Mexico, Canada, Great Britain, Norway, Sweden, Spain, Italy, Africa, Russia, India, French Indo-China, China, Japan, and Australia (New South Wales).

UNITED STATES.

MINE PRODUCTION.

Mine production of zinc in the United States, 1907–1915, in short tons.

	1907	1908	1909	1910	1911	1912	1913	1914	1915
Arizona	114	339	2,989	2,742	2,281	4,379	4,714	4,896	9,110
Arkansas	474	605	510	994	664	748	478	608	3,209
California	116	.....	.....	.....	1,404	2,173	529	195	6,547
Colorado	26,394	15,065	25,605	38,545	47,304	66,111	59,673	48,387	52,297
Idaho	3,493	19	676	2,802	4,170	6,953	11,587	21,006	35,077
Illinois	737	1,717	2,163	3,549	4,219	4,065	2,236	4,811	5,534
Iowa	145	395	35	96	.....	.....	.....	.....	.....
Kansas	17,772	14,119	11,445	13,229	10,272	10,633	10,088	11,284	14,365
Kentucky	.....	.....	56	6	158	491	327	230	764
Missouri	116,752	107,404	130,162	128,589	122,515	136,551	124,963	105,994	136,300
Montana	122	820	4,680	15,819	21,905	13,459	44,337	55,790	93,573
Nevada	1,084	558	1,507	1,354	1,774	6,661	7,210	6,490	12,188
New Hampshire	.....	.....	.....	.....	.....	.....	15	6	24
New Jersey	69,369	67,165	82,510	68,678	77,445	69,755	72,156	74,253	116,618
New Mexico	375	1,788	6,543	9,044	5,119	6,783	8,262	9,202	12,702
New York	.....	.....	.....	.....	81	.....	.....	.....	2,455
North Carolina	.....	.....	.....	.....	.....	142	10	.....	.....
Oklahoma	1,657	4,529	7,806	6,394	5,150	5,769	11,664	13,992	14,314
Tennessee	109	344	596	966	1,117	2,191	5,583	10,425	16,461
Texas	22	18	.....	.....	.....	119	326	108	15
Utah	2,726	730	4,930	8,184	8,920	8,534	9,429	7,995	12,146
Virginia	.....	705	58	794	1,032	249	2,719	174	1,267
Washington	.....	.....	.....	.....	10	.....	.....	.....	122
Wisconsin	18,490	18,206	23,152	25,927	29,720	33,050	30,110	31,113	41,403
	259,951	234,526	305,423	327,712	345,260	378,816	406,416	406,959	586,491

The following table shows, for each zinc-producing State, the total quantity of zinc ore produced, and the output of each kind of zinc ore. The column headed "All other ore" includes lead ore, copper ore, copper-lead ore, and dry or siliceous ore, no zinc of consequence being recovered from any of them except in Colorado. "Dry" ores produced in that State in 1915 contained 3,110 short tons of recoverable zinc. This, as in other States, was concentrated from parts of the ore from certain counties, however, and was not distributed through the whole of the "All other ore" credited to Colorado in 1915. The total crude ore yielding either gold, silver, copper, lead, or zinc is given for each zinc-producing State, so that a comparison may be made of the relative extent of deep mining operations for all five metals in these States, the quantity of crude ore raised being the best measure for this purpose. The table discloses the fact that Missouri made nearly one-fourth of the crude-ore

production of the zinc-producing States, having an output of 15,573,700 short tons of crude ore, of which 10,505,900 tons was zinc bearing. Excluding iron ore, this was the largest production of metalliferous crude ore in the United States. Next in rank was Michigan, with 12,334,700 tons of crude copper ore; Utah ranks third with 10,451,445 tons of crude ore.

The table gives also the quantity of recoverable zinc contained in the crude ores of each State and the quantity of zinc recovered from each kind of zinc ore. The percentage of recoverable zinc contained in the zinc ore and the zinc-lead ore of each State is also shown. The recoverable zinc content of crude zinc ore ranged from 32.8 per cent in Nevada down to 1.3 per cent in Missouri, the Western States having uniformly the higher percentage. The average recoverable zinc content of the zinc ore of the United States in 1915 was 2.7 per cent, as against 2.8 per cent in 1914. Of the total mine production of zinc in 1915, a quantity corresponding to 75.6 per cent was derived from zinc ore, 23.8 per cent was derived from zinc-lead ore, and 0.6 per cent was recovered from all other ores. The figures of mine production of zinc are taken from the chapters on gold, silver, copper, lead, and zinc (mine production), in the various States, as indicated in the prefatory note, and the table as a whole is repeated from the chapter on metals and ores.

Mine production of zinc in the United States in 1915, in short tons.[a]

	Zinc ore.			Zinc-lead ore.			All other ore.		Total.	
	Crude ore.	Recoverable zinc content.	Percentage.	Crude ore.	Recoverable zinc content.	Percentage.	Crude ore.	Recoverable zinc content.	Crude ore.	Recoverable zinc content.
Arizona	40,458	4,888	12.1	47,916	4,198	8.7	9,524,185	24	9,612,559	9,110
Arkansas	110,000	3,209	2.9						110,000	3,209
California	19,646	6,531	33.2	200	16	8.0	2,982,933		3,002,779	6,547
Colorado	100,222	19,584	19.5	284,151	29,603	10.4	2,352,647	3,110	2,737,020	52,297
Idaho	111,428	11,218	10.1	513,525	23,832	4.6	1,783,893	27	2,408,846	35,077
Illinois	316,000	5,534	1.7				(*b*)		316,000	5,534
Kansas	709,400	14,365	2.0						709,400	14,365
Kentucky	[c] 10,000	764	7.6				(*b*)		10,000	764
Missouri	10,505,900	136,270	1.3				5,067,800	30	15,573,700	136,360
Montana	178,573	23,556	13.2	580,475	69,991	12.1	5,370,876	26	6,129,924	93,573
Nevada	24,816	8,037	32.8	16,940	4,130	24.4	5,076,864	21	5,118,620	12,188
New Hampshire		[d] 24								24
New Jersey	737,310	116,618	15.8						737,310	116,618
New Mexico	[e] 71,663	12,695	17.7				2,725,409	7	2,797,072	12,702
New York	14,398	2,455	17.1						14,398	2,455
Oklahoma	891,800	14,314	1.6						891,800	14,314
Tennessee	525,829	16,461	3.1				623,535		1,149,364	16,461
Texas	60	15	25.0				54,968		55,028	15
Utah	34,320	4,958	14.4	385,361	7,188	1.9	10,031,764		10,451,445	12,146
Virginia	3,200	589	18.4	15,568	678	4.4	3,991		22,759	1,267
Washington	3,111	122	3.9				83,566		86,677	122
Wisconsin	1,934,000	41,403	2.1						1,934,000	41,403
	16,342,134	443,610	2.7	1,844,136	139,636	7.6	45,682,431	3,245	63,868,701	586,491
Percentage of total zinc derived from each kind of ore		75.6			23.8			0.6		

[a] Prepared by J. P. Dunlop.
[b] Exclusive of fluorspar ore mined in southern Illinois and Kentucky from which a small quantity of lead is recovered in milling.
[c] Estimated.
[d] Part of zinc from unknown quantity of tailings.
[e] Includes lead-zinc ore.

Mining districts, like metallogenetic provinces, pay little heed to the artificial restrictions of political boundaries. The following table has been compiled to show the zinc production of individual districts so that they may be compared as to extent of zinc mining operations, shown by the output of crude ore, as to character of ores, whether sulphide or oxidized, whether lean or rich, and as to relative rank as zinc producers:

Districts producing 1,000 short tons of recoverable zinc in 1915.

District.		Crude zinc-bearing ore sold or treated.	Shipping ore and concentrates.				Total recoverable zinc content.	Percentage of total production.
			Sulphide.		Carbonate, silicate, and oxide.			
			Quantity.	Recoverable zinc content.	Quantity.	Recoverable zinc content.		
		Short tons.	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Short tons.*	*Per cent.*
Joplin	Missouri, Kansas, Oklahoma	12,105,000	297,101	155,782	24,594	8,762	164,544	28.1
Franklin Furnace	New Jersey	737,310	.....	.....	623,702	116,618	116,618	19.9
Butte	Montana	700,845	207,475	93,231	.....	.....	93,231	15.9
Upper Mississippi Valley	Illinois, Wisconsin	2,250,000	159,450	46,392	2,579	545	46,937	8.0
Leadville	Colorado	219,147	136,555	20,870	82,592	15,342	36,212	6.2
Coeur d'Alene	Idaho	619,481	89,602	34,843	.....	.....	34,843	5.9
East Tennessee	Tennessee	525,829	23,771	12,943	11,712	3,518	16,461	2.8
Hanover, Cooks Peak, Kelly (Magdalena), Pinos Altos, Tres Hermanas, Florida	New Mexico	71,646	[a]41,852	12,691	.....	.....	12,691	2.2
Chalk Creek, Breckenridge, Red Cliff, Eureka	Colorado	215,528	[a]115,271	12,489	.....	.....	12,489	2.1
Yellow Pine	Nevada	36,323	.....	.....	33,734	10,530	10,530	1.8
Wallapai (Union Basin)	Arizona	84,953	26,406	8,691	.....	.....	8,691	1.5
Shasta	California	10,322	10,322	4,199	.....	.....	4,199	.7
Park City	Utah	180,345	11,162	3,886	.....	.....	3,886	.7
Northern Arkansas	Arkansas	110,000	606	316	7,925	2,893	3,209	.6
Bingham	Utah	209,333	6,550	2,746	.....	.....	2,746	.5
Edwards	New York	14,398	5,618	2,455	.....	.....	2,455	.4
Cerro Gordo	California	9,024	.....	.....	9,024	2,328	2,328	.4
Tintic	Utah	7,029	.....	.....	7,029	1,923	1,923	.3
Frisco	Utah	14,902	3,998	1,412	.....	.....	1,412	.2
Pioche	Nevada	4,237	4,237	1,290	.....	.....	1,290	.2
Southwestern Virginia	Virginia	20,369	5,742	1,267	.....	.....	1,267	.2
Promontory	Utah	4,788	.....	.....	4,788	1,241	1,241	.2
Total		18,150,809	[a]1,145,718	415,503	807,679	163,700	579,203	98.8
All other districts		.....	.....	.....	.....	.....	7,288	1.2
Total for United States		.....	.....	.....	.....	.....	586,491	100.0

[a] Includes some carbonate and silicate ores.

REVIEW BY STATES.

In the following brief reviews of the zinc production and resources of the various States the figures of mine production have been taken partly from the annual reports on mine production of gold, silver, copper, lead, and zinc in the particular State as published in Mineral Resources of the United States for the years indicated. Unless

otherwise stated the quantities of zinc refer to recoverable zinc in ores and other material sold or treated during the calendar year—that is, allowance has been made for loss of zinc in smelting. In comparing the values of ore and metal, in the tables where such values are given, it should be borne in mind that the value given for the ore or concentrate is that actually received by the producer, while the value of the zinc in 1915 is calculated from the average sales price reported by the smelters, and for the years prior to 1915 is calculated from the average daily quotations at St. Louis. In preparing the discussion of zinc resources of each State, use has been made of the mines reports in Mineral Resources as noted above, of the Government and State geological reports, of company reports, and of mining literature in general. Weed's Mines Handbook has also been of much assistance. The time for compilation has been necessarily short, and it is more than likely that some errors have crept in.

NEW ENGLAND STATES.

Numerous mines and prospects of complex silver-lead-zinc sulphide ore, with pyrite and chalcopyrite, have been opened in the New England States, but no important production of zinc has come from that region. Brief descriptions of most of these prospects, with footnote references to the literature, will be found in the chapter on gold, silver, copper, lead, and zinc in the Eastern States in Mineral Resources for 1908.

In Maine the Deer Isle zinc-lead mine, in Hancock County, was opened about 1875, but was not profitably worked. It was reopened in 1906 and 275 tons of ore carrying 25 per cent zinc and 9 per cent lead and traces of gold and silver were taken out during that year and the first half of 1907. No ore has been taken out since. A deposit of zinc carrying a little argentiferous galena was discovered near Cherryfield, Washington County, in 1878, and opened to a depth of 100 feet, and a concentrating plant was erected. This mine was reopened in 1906 and actively prospected to the 200-foot level, and 40 tons of ore was shipped. No further production has been made.

In New Hampshire, near Warren, Grafton County, the mine of the Warren Zinc Separating Co. is said to have opened a large deposit of complex sulphide ore which runs 35 per cent zinc and 10 per cent lead, with 10 to 12 ounces of silver to the ton. According to Hitchcock[1] the ore occurs as a well-defined shoot in mica schist lying within the gneiss and the ore is associated with tremolite and quartz. The mine was worked actively in 1906, but difficulty was found in concentrating the ore though roasting and magnetic separation were employed. Some small shipments of concentrates produced at this mine in 1906 were made in 1913 and 1914 to the Johnson experimental electrothermic zinc smelter at Hartford, Conn. The mine has not been operated since 1906. It was at this mine that the Lungwitz process of smelting zinc in the blast furnace, under sufficient pressure to prevent vaporization, was unsuccessfully tried out in 1906. At Woodstock, also in Grafton County, a deposit of lead-zinc sulphides, in a vein in the gneiss, was worked in 1906, but has not been operated since. The Silver Lake mine near Madison, the mine at West Ossipee, and the mine at Eaton, all in Carroll County,

[1] Hitchcock, C. H., The geology of New Hampshire, pt. 5, pp. 48–49, 1878.

contain complex sulphide ores which have been prospected for lead, but contain more zinc than lead, especially in depth. Other similar deposits are near Shelburne and Gorham, in Coos County.

In Lamoille and Windsor counties in Vermont, in Hampshire and Essex counties in Massachusetts, and in Litchfield County in Connecticut there are unimportant deposits of mixed sulphide ores.

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RESOURCES.

It is uncertain whether the early operations described below produced any zinc ore that was marketed. In 1911 there was a production of 680 tons of zinc sulphide ore, from which 81 tons of spelter was recovered. In 1912 about 100 tons of zinc sulphide ore was shipped, which yielded 14 tons of spelter. There was no zinc production in 1913 or 1914. In 1915 the production was 14,398 tons of crude zinc ore, which yielded 5,618 tons of zinc concentrates containing 2,455 tons of recoverable zinc. All of the zinc output from 1911 to 1915 came from the Edwards mine.

In southeastern New York, lead and zinc mines have been worked at Guymard, Orange County; at Wurtsboro, Sullivan County; and at Ellenville, Ulster County. These deposits occur, according to Ihlseng,[1] near the contact of the sandstone and conglomerate forming Shawangunk Mountains, with the underlying shales, both formations dipping northwest about 40°. The Ellenville mines were worked in 1820, about 1854, about 1870, and in 1903; the last time a deposit of zinc and copper ore was opened at 175 feet in depth. At both these mines lead was predominant near the surface but gave way to zinc lower down. About 1837 considerable work was done at the Wurtsboro mines and about 100 tons of lead ore was mined; the zinc ore, however, greatly exceeded the lead in quantity in the mine. The St. Nicholas Zinc Co. is reopening the Wurtsboro mine and will have a 100-ton mill finished by the close of 1916. The ore in the upper part of the mine was formerly worked for lead, but zinc is reported to increase with depth.

Zinc ore was discovered near Edwards, St. Lawrence County, N. Y., in 1906, although the Balmat deposit, 12 miles southwest, carrying mixed lead, zinc, and iron sulphide ore, has been known since the beginning of the last century. The ore bodies at Edwards and Balmat as well as the intervening showings are in an elongated body of crystalline limestone, 15 miles long and from 2 to 3 miles wide, which is folded into the pre-Cambrian gneiss of the Adirondacks. The Northern Ore Co., owner of both the Balmat and the

[1] Ihlseng, A. O., The zinc mines at Ellenville, N. Y.: Eng. and Min. Jour., vol. 75, p. 630, 1903.

Edwards properties, has spent much time in developing the property and perfecting a process for the separation of blende from pyrite and barite. This was finally accomplished by the Weatherby magnetic tables as noted on page 946. The first mill was burned in 1914 and the present mill was completed in March, 1915. The mine is producing about 900 tons monthly of 50 per cent zinc concentrates and the output for 1916 should be double that for 1915. The crude ore ranges from 10 to 40 per cent zinc, averaging about 19 per cent zinc in 1915. The mine is opened by two inclined shafts 650 feet apart and connected underground on the 400-foot level. The present production is coming mostly from the Brown shaft, which is 550 feet deep, with working levels at each 100 feet in depth. This shaft follows a lens of solid blende and pyrite about 5 feet thick at the surface, swelling to 14 feet at the 150-foot level and thinning somewhat below that. The dip is northwest and varies from 25° near the top to 60° at the bottom. A second lens, 4 feet in thickness, reaching from 60 to 160 feet in depth, and at least 250 in length, is intersected by crosscuts into the hanging wall. The ore bodies are irregular in strike and thickness, extend from northeast to southwest, and vary from a few inches to 14 feet in thickness. The lateral extent of the main lens has not been determined, though known to be more than 600 feet long, and it shows no signs of exhaustion in depth. A new shaft is now being started which is expected to reach a depth of 1,000 feet. It is reported that ore reserves of a million tons have been proved by present development. A typical assay of the crude ore shows zinc sulphide, 25.5 per cent; lead sulphide, 1.43 per cent; iron sulphide, 12.4 per cent; ferric oxide, 1.8 per cent; barium sulphate, 3.97 per cent; magnesium silicate, 21.5 per cent; magnesium carbonate, 10.9 per cent; silica, 10.7 per cent; and alumina, 2.8 per cent. The ore is an intimate fine-grained mixture of sphalerite, pyrite, and a little galena. The principal gangue minerals are dolomite, a lime-magnesia silicate which alters to serpentine and talc, and a little barite. Other prospects in the Edwards district are being opened up and a custom concentrator is planned

NEW JERSEY.

PRODUCTION.

Mine production of zinc in New Jersey, 1911–1915, in short tons.

District.	Crude zinc ore.	Zinc shipping ore and concentrates.	Recoverable zinc content.
Franklin Furnace, 1915	737,310	623,702	116,618
1914	529,443	464,088	82,338
1913	490,434	426,307	79,944
1912	459,585	394,047	75,214
1911	374,064	320,636	65,234

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RESOURCES.

New Jersey was an early producer of zinc ores, and her output has been continuous and large. The Franklin Furnace mines are famous for the long time that they have been producing, for the quantity and quality of their zinc, and for their unique assemblage of zinc minerals—zincite (ZnO), willemite (Zn_2SiO_4), and franklinite ($[Fe,Zn,Mn]O.[Fe,Mn]_2O_3$). As early as 1774 a shipment of red zincite ore from this locality was made to England under the impression that it was copper ore. Spelter was first made in this country about 1838 from zincite ore mined at Franklin Furnace. Only one small lot was turned out, and this was used in making the brass for the United States Government standard set of weights and measures. According to J. D. Whitney, the only zinc produced in this country in 1853 and 1854 was recovered in the form of zinc oxide from New Jersey ores. About this time the method of manufacturing zinc oxide was greatly improved, and thereafter considerable Franklin Furnace ore was used for this purpose. Previously the oxide had been produced in a small way only and a yellowish paint pigment had been made by simply grinding up the red zincite ore. Spelter from refuse zinc oxide from New Jersey ores was first manufactured about 1865. For many years unsuccessful efforts were made to use the franklinite as a source of manganese iron until it was accidentally discovered that if anthracite coal is mixed with the ore and the mixture highly heated, the zinc is distilled off and on contact with air is immediately condensed as zinc oxide. The residuum containing iron and manganese is available for smelting into spiegeleisen, which is used in making steel by the Bessemer process. Hence all the franklinite concentrates are used in making zinc oxide and all the willemite concentrates are used in making spelter. Franklin Furnace ore, containing no lead or cadmium, yields a high-grade spelter, the well known Horsehead brand, and the great demand for spelter of this grade during the last two years has resulted in a notable increase of the zinc output of these mines. A moderate estimate of the zinc output of the Franklin Furnace mines since 1852 is 8,700,000 short tons of ore, from which 1,500,000 tons of zinc has been recovered in the form of spelter and zinc oxide.

The Franklin Furnace mines, of the New Jersey Zinc. Co., are in Sussex County, at Mine Hill, near Franklin Furnace, and at Sterling Hill, 2½ miles south of Franklin Furnace. The following notes on the mines are compiled from the description by A. C. Spencer in the Franklin Furnace folio, and from information of recent developments kindly furnished by the New Jersey Zinc Co.

The zinc deposits are in a belt of white limestone, here less than half a mile wide, flanked on the southeastern side by a down-faulted area of blue limestone and quartzite and on the northwestern side by an area of gneiss. Stratification in the white limestone can be made out in places, but in the main the bedding is obscured by foliation that has resulted from metamorphism of the limestone. It has been thought by some that the zinc ore bodies represent true strata, which

either originally contained the metals or were of such a nature as to be more liable to replacement than the other strata. The ore bodies at Mine Hill and Sterling Hill are in the form of synclinal folds or troughs plunging to the north, with the planes of the axes inclined to the southeast parallel to the foliation. The limbs of the folds are of unequal length, which results in a hook-shaped outcrop for each ore body, the east limb being longer at Sterling Hill and the west limb at Mine Hill. The longer limb of the Mine Hill ore body lies adjacent to the contact with the gneiss, but a band of magnetite occupies the actual contact along a portion of the ore body and for some distance south The outcrop of the Sterling Hill ore body is more than 1,000 feet from the gneiss and about 700 feet from the fault at the junction of the white and blue limestones but dips toward the fault and may be cut off by it in depth. At Sterling Hill there is a conformable sheet of pegmatite inside the trough and about 10 or 15 feet from the ore body. Pegmatite is intruded at Mine Hill also, both in the ore body and in the limestone adjacent to it. Spencer suggests that these deposits are related in origin to the magnetite deposits of the pre-Cambrian area of New York and New Jersey, most of which contain small proportions of manganese and zinc. As the magnetite deposits are most likely due to igneous action, that origin is assigned for the Franklin Furnace deposits.

The Sterling mine, at Sterling Hill, was worked for calamine and smithsonite about 1875, and underground mining for zincite and franklinite continued until 1897, since which time the mine has been practically closed until very recently. At the time operations were suspended, open pits for calamine and smithsonite had been worked in the limestone area within the outcrop of the ore body, and the east limb of the ore body had been followed downward to depths at different places of from 250 to 560 feet and had been found to range from 10 to 30 feet in thickness. An incline shaft was recently sunk on this ore body to a vertical depth of 1,600 feet and levels were driven southward on the ore body and around the trough at 1,100 and 1,400 feet; northward from the shaft the 1,400-foot level runs into a faulted zone. A new mill of 400 tons capacity in 24 hours and similar to the mill at the Franklin mine has been built at the Sterling mine.

The Franklin mine, at Mine Hill, has been worked since 1850. The ore body outcrops for a distance of 2,600 feet along the contact with the gneiss on the western arm of the hook; the eastern arm is about 600 feet long. The total length of the bottom, or keel, of the trough is about 3,500 feet and its depth at the lowest point is 1,100 feet. The ore body ranges from 12 to 100 feet in thickness, the thickest portion being in the keel of the trough. Since 1908 the drifts on the various levels at the north end of the mine have been connected with those on the south. A new five-compartment incline shaft opening near the mill has been connected with all levels, and all ore is delivered to the mill without surface haulage Underground electric haulage delivers the ore to the skips through automatic measuring pockets. Developments during recent years have been directed toward economy in extraction of ore. The mill has a capacity of 2,500 tons in 24 hours. Crushing and sizing is followed by magnetic separation, which removes franklinite and manganese minerals and garnet. The nonmagnetic product is treated on jigs and tables to separate the willemite from the gangue minerals.

PENNSYLVANIA.

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RESOURCES.

The principal zinc and lead deposits of Pennsylvania are in the Saucon Valley, in Lehigh County, and smaller deposits are at the Bamford mine, in Lancaster County, and at the Sinking Valley mines, in Blair County. The Saucon mines are the only ones which have had an important output or which are likely to have such an output in the future. These mines have been well described by Clerc, from whose report, and from Miller's, the following notes are condensed.

There are three mines—the Ueberoth, the Hartman, and the Saucon, or Correll. The Ueberoth mine was worked continuously from 1853 to 1876, later for a short time in 1883, and again for a short time in 1886. It furnished the greater part of the ore for the Lehigh Zinc Works and produced about 300,000 tons of ore. The ore came close to the surface, and a rich pocket of carbonate and silicate in clay surrounding limestone bowlders yielded one-third of the total output of the mine. The other part of the ore came from a vertical system of parallel crevices, which at 225 feet, the total depth of the mine, showed no evidence of pinching out. In the lower part of the crevices there was sphalerite. To handle the great quantity of water in this mine the largest pumping engine in the world was installed. The Hartman mine, about a half mile from the Ueberoth mine, was worked to a depth of 150 feet, at first for calamine, but as the mine got deeper the calamine gave place to sphalerite. The Saucon, or Correll, mine is a quarter of a mile from the Hartman mine. It was first worked for calamine by the open-pit method, but zinc blende was found in part of the mine and developed into an ore body which was worked to a depth of 200 feet.

Since 1893 there has been no ore mined at any of these mines, which, together with considerable adjoining land, now belong, according to Miller, to the New Jersey Zinc Co., which did prospect drilling in 1914–15. The cause of closing the Ueberoth mine in 1876 was the expense of necessary pumping, which prevented successful competition with the New Jersey mines. There was no indication of lack of ore, and it is possible that all three mines may again become large producers of zinc ores. At this writing (November, 1916) it is reported that all arrangements have been made to begin unwatering the mines.

VIRGINIA.

PRODUCTION.

Mine production of zinc in Virginia, 1911–1915, in short tons.

District.	Crude zinc ore.	Shipping ore and concentrates.	Recoverable zinc content.
Southwestern Virginia, 1915	20,369	5,742	1,267
1914	14,004	1,204	174
1913	30,034	11,000	2,719
1912	4,935	2,167	249
1911	16,024	9,423	1,032

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RESOURCES.

In Virginia only lead ores were mined prior to 1876. In 1879 the zinc mines at Bertha, Wythe County, were opened and soon afterwards zinc distillation furnaces were built at Pulaski, which were operated until 1911. The remarkable purity of the spelter made from the ore mined there gained for it a wide reputation for excellence.

The zinc deposits of Virginia are found in two regions—in the limestones of the Great Valley region in Botetourt, Roanoke, Pulaski, Wythe, Smyth, and Russell counties, and in the crystalline rocks of the Piedmont region in Albemarle, Louisa, and Spotsylvania counties. Each region has its own characteristics as to composition of the ores and gangue.

The Bertha and Austinville mines, in Wythe County, have been the chief producers of zinc ore in Virginia and have probably produced nine-tenths of the zinc output of the State. The Bertha mines are situated a mile south of New River and within 2 miles of the eastern border of the county. The ores first worked were oxidized ores, carbonate and silicate of zinc, found in the residual clays surrounding pinnacles or "chimneys" in the Shenandoah limestone. The ore was mined by open pits and shallow shafts. Drilling showed disseminated blende in the limestone below but not in sufficient quantity to work. Considerable iron is found in the residual clays, and in 1898 and afterward the Bertha mine was worked for iron ore. The Austinville mines also are owned by the Bertha Mineral Co. (New Jersey Zinc Co.). They are located on the east side of New River where it enters Wythe County from the south. Lead ores were first worked here in 1750. There is a concentrating plant and a zinc oxide plant at the mines. There was formerly a lead smelter, and as late as 1880 shot was made by letting the molten lead drop down a shaft 242 feet deep. The zinc ores first worked were the silicate and the

carbonate, which were associated with lead carbonate in the residual clays surrounding the limestone "chimneys." The ore was mined by open pits and by underground mining, the latter consisting of shafts and of three long adits or tunnels leading from the surface to beneath the open pits and reaching vertical depths of 250 feet. The main levels worked were at 90, 180, and 238 feet, but the workings now reach a depth of 471 feet. Ores similar to those at Austinville occur near Ivanhoe Furnace, 2 or 3 miles farther west, and are now being worked. Blende, galena, and pyrite are also found closely associated with masses of barite. In the same trend up the valley of Cripple Creek zinc blende has been opened by prospecting at Cedar Springs, about 20 miles from Austinville, also a few miles farther west in Rye Valley, and in several places between Rye Valley and Holstein Mill. Other openings are at Allisonia in Pulaski County and in Russell, Bland, Roanoke, and Botetourt counties. Zinc ores are said to have been recently found in several drill holes near New Market, Shenandoah County.

The Albemarle mine, in Albemarle County, near Faber, is on a vein traceable for several miles and averaging 4 feet in width. Three shafts have been prospected in the vein to a depth of 300 feet and for 1,000 feet in length. The vein is in crystalline schists, and the ores are associated with fluorspar and quartz. The mine was cleaned out and the mill overhauled in the latter part of 1915 and development work was prosecuted in 1916.

Perhaps the most promising zinc area in Virginia just at present is the pyrite belt of Louisa and Spotsylvania counties. This belt and its northward extension into Prince William County has had for many years a larger output of pyrite than any other district in the United States. In Louisa and Spotsylvania counties the pyrite belt has a width of 4 or 5 miles. The country rock is, in the main, quartz sericite schist, according to F. B. Speed, jr.,[1] who says:

> The larger ore bodies occur in the less siliceous portions of the schist series and occupy fissured positions. Replacement of the wall rock by sulphides on the hanging wall side chiefly is characteristic of the deposists, the footwall being usually well defined and the hanging wall less so. In places this replacement has been very extensive, certain of the ore bodies showing a thickness of 60 feet or more. The presence in association with the sulphides of such minerals as hornblende, garnet, pyrrhotite, and zinc spinel classifies these occurrences as high-temperature deposits.

Prof. J. H. Cline[2] says:

> In texture the lead and zinc ores and the pyrite ores are practically identical. They differ only in the proportions of the various sulphides present. For instance, the pyrite ores are composed of granular pyrite, with disseminated grains of galena and blende, while the lead and zinc ores are composed essentially of the two latter sulphides, with disseminated grains of pyrite.

The Arminius mine, near Mineral, has produced pyrite for many years, being developed to a depth of 1,300 feet. Small shipments of copper, lead, and zinc sulphide concentrates were made in 1911. None have been reported since, though the ore is reported to carry an average of 4 per cent of zinc. In 1915 some lead and zinc concentrates were recovered in producing pyrite at the Allah Cooper mine.

[1] Speed, F. B., jr., Lead-zinc mining in Virginia: Eng. and Min. Jour., vol. 102, pp. 511–512, 1916.
[2] Cline, J. H., The Louisa-Spotsylvania, mineral district of Virginia: Manufacturers' Record, p. 50, July 20, 1916.

The Holladay mine, under development for several years, has been brought to the producing stage by the Virginia Lead & Zinc Corporation. This company owns 743 acres of land and controls 527 acres in addition. The property is developed by two shafts 123 and 206 feet deep and 1,200 feet apart on the vein, and about 800 feet of drifting on the 100, 150, and 200 foot levels. A report issued by the company in July, 1916, gives 50,000 tons as a conservative estimate of ore reserves developed at that time, but recent work has shown that this estimate should be greatly increased. An average of 90 samples gave 9 per cent lead, 17 per cent zinc, 0.2 per cent copper, and 6.5 per cent manganese, but 1,665 tons shipped up to October, 1916, averaged 4.5 per cent lead and 12.75 per cent zinc. A branch railway, costing $65,000, is under construction to connect with the spur leading from Mineral station on the Chesapeake & Ohio Railway to the Allah Cooper mine, and will be completed by February 1, 1917. The Virginia Lead & Zinc Corporation late in 1916 purchased the Allah Cooper mine and concentrating plant. The mill will be enlarged to a capacity of 100 tons a day. A mill site has been acquired on Anna River at the crossing of the branch railway, and in time a large mill will be erected, the concentrating system being based on the results of operating the small mill.

NORTH CAROLINA.

The only lead and zinc deposits of importance in North Carolina are those in the Silver Hill or Cid district, in Davidson County, described by Pogue.[1] The Silver Hill mine, which has been worked at various times, was discovered in 1838. The first ore mined was lead carbonate containing disseminated plates of native silver. Sulphide ores were soon reached, and the later history of the mine is concerned largely with repeated attempts to handle the mixed sulphide ore consisting of galena, sphalerite, chalcopyrite, and pyrite and containing about 20 per cent lead, 40 per cent zinc, 0.5 per cent copper, 9 per cent iron, and some gold and silver. The total depth of the mine workings is 725 feet on the vein or 570 feet vertical. The mine was last operated in 1910–1912 and produced concentrates which yielded 152 tons of zinc and 81 tons of lead.

The Silver Valley mine, a few miles northeast of Silver Hill, has similar mixed sulphide ore. The mine was worked to a depth of 210 feet in the early eighties but has had no recent output. Difficulties of concentration seem to have been the trouble at these mines. The successful working of mixed sulphide ores elsewhere and the recent opening of mines of zinc ore mixed with other sulphides in New York and Virginia suggest the possibility that these mines in North Carolina may yet make important contributions to the zinc output of the United States.

[1] Pogue, J. E., jr., Cid mining district of Davidson County, N. C.: North Carolina Geol. and Econ. Survey Bull. 22, p. 144, 1910.

TENNESSEE.

PRODUCTION.

Mine production of zinc in Tennessee, 1911–1915, in short tons.

District.	Crude zinc ore.	Concentrates.				Total recoverable zinc content.
		Sphalerite.		Silicate and carbonate.		
		Quantity.	Zinc content.	Quantity.	Zinc content.	
Eastern Tennessee, 1915	525,829	23,771	12,943	11,712	3,518	16,461
1914	357,437	14,706	8,002	8,000	2,423	10,425
1913	171,392	5,218	2,844	8,515	2,739	5,583
1912	32,347	.....	.....	5,690	2,191	2,191
1911	22,564	123	60	3,120	1,057	1,117

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RESOURCES.

The zinc ores of Tennessee are much more abundant than the lead ores, the latter being found in few of the mines. With few exceptions these ores are found in the Knox dolomite, in brecciated areas adjoining fault zones of low inclination that mark the system of overthrust faults in eastern Tennessee. The lead and zinc deposits occur chiefly along four belts trending northeastward. The belt lying farthest northwest lies parallel to Powell River and includes the Straight Creek mine near Tazewell, Claiborne County, and the openings in the Lead Mine Bend area in Union County, the principal one being the New Prospect mine. Lead and zinc ores are also found at intervals for a distance of 9 miles southwest of the New Prospect mine, and it is reported that prospecting has disclosed a considerable deposit of zinc ore near La Follette, Campbell County. The Straight Creek mine has been worked intermittently for 25 years; it yielded oxidized zinc ores formerly and zinc blende in later years. The New Prospect mine was worked for lead during the Civil War, and a large open pit and a wide tunnel were excavated. Lead ore is not now prominent and recent operations have had only zinc ores in view. The workings consist of a stope or tunnel 40 feet wide, 25 feet high, and 600 feet long, inclined at an angle of 5°. Both carbonate and sulphide ores of zinc are produced. In 1916 the old mill was remodeled and flotation equipment was added by the Southern Minerals Co.

The southeasternmost belt is mostly in Jefferson County, adjacent to French Broad River, and embraces the openings at Leadvale and

at Dandridge. In both these mines the zinc ore is intimately mixed with lead ore, which makes the clean separation of the minerals difficult.

The northeasternmost belt includes the Fall Branch mine in Sullivan County and the prospects near Jearoldstown in Greene County. The Fall Branch mine is equipped with a dry concentration mill which has not been operated for several years. The ore is chiefly zinc blende with some carbonate and silicate. There is no lead.

The central belt extends for more than 25 miles along the Holston River valley from Knoxville northeastward in Knox and Jefferson counties. The Chatata lead and zinc prospects near Charleston, Bradley County, and the Blue Spring lead mine, 6 miles southwest of Cleveland, in the same county, are apparently on a southwestern continuation of the central belt, though separated from it by a wide gap. It is in this belt, northeast of Knoxville, that much of the active work of recent years has been done. The ores of this northeastern part of the belt are exclusively zinc ores, carbonate and blende, and are quite free from lead and iron. The spelter made from them is, in consequence, of high quality. The Roseberry mine near Mascot, Knox County, was opened in 1883 and produced carbonate ore from an open cut, which is 50 feet wide by 200 feet long. The mine was equipped with a small mill, and a shaft was sunk to a depth of 200 feet. It has been recently operated by the Grasselli Chemical Co.

The American Zinc Co. of Tennessee acquired the Holston mine in 1910 and in 1912 built a 1,000-ton mill. This mine yielded blende and carbonate ore from an open cut when first opened, but in 1905 underground mining for sulphide ore was begun at a depth of 150 feet. The mill was remodeled and enlarged by the Holston Zinc Co. in 1908. Under the American Zinc Co. the property, comprising more than 2,500 acres, has been developed into one of the large zinc producers of the country. In 1915 the Roseberry property also was purchased and a 700-ton mill was erected. The 1,200-ton mill at Mascot was increased to 2,200 tons, giving an aggregate daily milling capacity of about 3,000 tons. Both plants are equipped with flotation machinery. There are three mines, two on the Mascot property and one on the Roseberry tract. Those on the Mascot property are operated by two 4-compartment shafts, 280 and 520 feet in depth, respectively, and by several thousand feet of drifts. The new shaft on the Roseberry tract is 180 feet deep. The annual report of the company for 1914 credited the property with ore reserves of about 6,000,000 tons, but the purchase of the Roseberry property, together with current development work, must have increased the reserves materially. The crude ore is said to average between 4 and 5 per cent zinc, and the concentrates to average over 60 per cent zinc. The spelter produced from this ore is marketed as "Mascot" high grade. The ore is zinc blende, with only traces of lead and iron. It is found in breccias, which are in the main parallel to the inclined bedding of the rocks but at places cut across the bedding. The gangue consists of broken dolomitic limestone, with dolomite and some calcite. The breccia beds and consequently the ore bodies dip from 15° to 40° SE., the average being about 20°. The strike of the

breccia zinc is northeast, parallel to the strike of the main folding and the folding of the region. The ore bodies are irregular, having a thickness of over 100 feet at places and pinching out at others. One cause of the irregularity is "tightness" of the ground—that is, areas which are less brecciated and offer less opportunity for ore deposition. The lower side of the ore bodies is more regular than the upper.

The Loy mine at Newmarket, Jefferson County, opened in 1892, has yielded silicate and carbonate ores from residual clays. The property has been actively operated by the Grasselli Chemical Co. for many years. The Newmarket or Ingalls mine was operated until 1911 by the Tennessee Mineral Co. It produced large quantities of ore, both carbonate and blende, from an open pit 50 feet in width and 165 feet in length. The Russell & Pendergrass mine, near Newmarket, produced considerable high-grade zinc carbonate ore in 1914 and 1915 from shafts less than 50 feet in depth. The Mossy Creek mine, at Jefferson City, has large workings consisting of an open cut 600 feet long, 75 feet wide, and 40 feet deep. The ores mined here were carbonates and silicates, with blende intermixed in places. The Branner and College mines, also at Jefferson City, show similar large open-cut workings.

One of the most important and interesting deposits of zinc in the State is that in Bumpass Cove, in Unicoi County, near Embreeville. For about 70 years limonite iron ore, occurring in residual clays, has been mined here. Late in 1912 it was discovered that the residual clay surrounding the pinnacles of limestone contained zinc carbonate and silicate ores. Beginning with 1913 important shipments have been made of these ores. The ore shipped at first was simply hand picked, but later washing and separating machinery was installed. No doubt in the past much zinc ore must have washed away in recovering the iron ores, which were washed out of the clays by hydraulic jets. Much zinc must also have been lost by volatilization in smelting the iron ore. The ore horizon is reported to be near the base of the Shady limestone, of Cambrian age. This limestone occurs considerably lower in the geologic column than the Knox dolomite, with which practically all the other zinc deposits of Tennessee are associated. With the weathering and decomposition of the limestone the original zinc sulphide ores were altered to zinc carbonate and zinc silicate and were residually concentrated in the clays. Some zinc sulphide is found in the limestone, but none has been mined. A little galena occurs with the zinc ore at places. Two companies are operating, the Embree Iron Co. and the Tennessee Zinc & Lead Co. The latter company cleans its ore in a log washer, but the Embree Iron Co. has a 100-ton concentrating plant, consisting of log washers, picking belts, crushing and sizing machinery, magnetic separators, and concentrating tables. The pits from which iron ore was worked and which now yield zinc ore cover a distance of 2 miles on the south side of the cove.

KENTUCKY.

PRODUCTION.

Mine production of zinc in Kentucky, 1911–1915.

District.	Zinc concentrates.				Recoverable zinc content.	
	Sphalerite.		Zinc carbonate.			
	Quantity (short tons.)	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Western Kentucky, 1915	.....	.....	2,172	$106,079	764	$189,472
1914	27	$1,120	644	12,168	230	23,460
1913	198	5,206	696	13,811	327	36,624
1912	498	25,391	750	16,006	491	67,758
1911	.....	.....	467	10,604	158	18,012

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RESOURCES.

Lead and zinc deposits are found in the central and western parts of the State. The ore deposits of central Kentucky are in Mercer, Scott, Franklin, Owen, Henry, and adjoining counties, in rocks of Lower Ordovician age. The ore, mostly lead, occurs in veins associated with such gangue minerals as barite, fluorite, and calcite. In many of the veins zinc blende occurs with the galena, but no shipment of zinc ore has ever been made from this district, and none of lead for several years.

The lead and zinc deposits of the western or fluorspar region of Kentucky are found chiefly in Caldwell, Crittenden, and Livingston counties, but continue north across Ohio River, forming the southern Illinois lead and fluorspar region in Pope and Hardin counties; they also extend southward in local deposits in western Tennessee. The deposits are principally in rocks of the Chester and Meramec groups, of Mississippian age. The ores are galena, sphalerite, and smithsonite and occur in association with such gangue minerals as fluorspar, barite, and calcite.

The ores occur in veins, in breccias, and as metasomatic replacements, mainly within or adjacent to zones of faulting. The gangue is composed of fluorspar, barite, calcite, and jasperoid, but no dolomite. In several mines and prospects the ore occurs in contact with or adjacent to dikes of mica peridotite. Considerable quantities of both lead and zinc ores have been produced in the past. At the present time lead concentrate is produced chiefly as a by-product in

the concentration of fluorspar, but zinc carbonate ore in many mines is free from fluorspar and has been extensively mined.

The production of zinc ore in the district from about 1900 to 1905 ranged between 1,500 and 2,500 tons, but after that it decreased considerably until 1915. The Old Jim mine, in Crittenden County, was one of the largest producers, having an output of 1,677 tons of carbonate ore in 1901 and of 2,518 tons in 1902.

The output of zinc carbonate ore in 1915 was more than three times as large as during any other recent year. In 1915 the principal producers were the Hudson mine in Livingston County and the Miller and Tabb mines in Crittenden County. The Hudson mine was operated as an open cut and the ore was cleaned on a log washer.

ILLINOIS.

PRODUCTION.

Mine production of zinc in Illinois in 1911–1915.

District.	Zinc concentrates.				Recoverable zinc content.	
	Sphalerite.		Zinc carbonate.			
	Quantity (short tons.)	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Northern Illinois, 1915	20,454	751,277	.....	.....	5,534	$1,372,432
1914	16,725	320,012	.....	.....	4,811	490,722
1913	8,148	156,664	120	$1,603	2,236	250,432
1912	13,464	367,537	.....	.....	4,065	560,970
1911	11,011	320,806	.....	.....	4,219	480,966

Tenor of lead and zinc ore and concentrates produced in Illinois, 1911–1915.

	1911	1912	1913	1914	1915
NORTHERN ILLINOIS.					
Total crude ore.....short tons..	153,313	147,859	119,200	261,300	316,000
Total concentrates in crude ore:					
Lead.....per cent..	0.6	0.6	0.6	0.25	0.22
Zinc.....do....	7.2	9.1	6.9	6.4	6.5
Metal content of crude ore:					
Lead.....do....	.4	.4	.5	.19	.17
Zinc.....do....	3.2	3.2	2.4	2.3	2.18
Average lead content of galena concentrates...do....	79.4	79.5	78.1	76.2	72.9
Average zinc content of sphalerite concentrates.do....	45.3	35.4	34.8	36.5	33.5
Average zinc content of zinc carbonate concentrates, per cent.....	.....	.....	29.5	.....	.....
Average value per ton:					
Galena concentrates.....	$52.37	$55.38	$53.80	$44.70	$47.27
Sphalerite concentrates.....	$29.13	$27.30	$19.23	$19.13	$36.73
Zinc carbonate concentrates.....	.....	.....	$13.36	.....	.....
SOUTHERN ILLINOIS.					
Average lead content of galena concentrates.per cent..	70.0	74.6	73.3	73.5	71.6
Average value per ton of galena concentrates.....	$44.00	$46.49	$46.08	$39.99	$43.45

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RESOURCES.

The lead and zinc deposits of Illinois fall into two distinct regions marked by different mineralogic association and structural environment. Those of southern Illinois belong to the Kentucky-Illinois fluorspar district; those of northern Illinois belong to the upper Mississippi Valley region.

The lead and zinc deposits of southern Illinois are found in Pope and Hardin counties in rocks of Mississippian age and are the northern extension of the Kentucky-Illinois fluorspar district. The structural relations and the mineralogic association are similar to the deposits of western Kentucky and in striking contrast to those of northern Illinois. The ores occur in fissure veins, in association with jointing and faulting. The mines have been worked to depths of 300 and 500 feet without disclosing any decrease in the dimensions of the ore bodies. Dikes and sheets of lamprophyre and dikes of mica peridotite occur in the vicinity, but not in direct connection with the ore deposits. The principal gangue minerals are fluorspar, calcite, and barite. Galena is the most important metallic mineral. Formerly, and nearer the surface, large bodies of galena were worked, but that mineral is at present produced incidentally in the concentration of the fluorspar. Sphalerite or zinc blende is the next important metallic mineral, but it is much less plentiful than galena. It is recovered as zinc middlings in the concentration of the fluorspar, but it is difficult to make a clean separation of the zinc, and none has been sold in recent years.

The lead and zinc mines of northern Illinois are all in Jo Daviess County, the extreme northwestern county. The ores have the same structural relations as in the upper Mississippi district generally, that is, they occur disseminated through the limestone or in openings in it called "crevices," "pitches," or "flats," depending on their attitude to the horizontal. These openings have in general an east and west trend, known as their "range." The ore bodies are sometimes continuous for long distances along these ranges, which for that reason largely control the prospecting, both by shafts and by drilling. The ore deposits occur in the Galena dolomite and in the upper part of the Platteville limestone, both of Ordovician age. The ores are galena, sphalerite, and smithsonite, though the latter is much less common now than formerly, when the deposits worked were mostly shallow and above water level. Iron pyrites is very commonly associated with the ores, frequently in such quantity as to necessitate roasting and magnetic separation. Some of the mining companies have calciners or roasters and magnetic separators, and there is a custom roaster and separator operated by the Galena Refining Co., at Galena, as well as custom separating plants near by in Wisconsin.

The zinc ores of Illinois first became of importance when the zinc smelter was built at La Salle, Ill., in 1858. After the Civil War zinc mining was active until the ores above water level were exhausted. After a considerable lull in mining operations the deposits below water level began to be worked, and zinc blende ores from these deeper deposits furnish all the zinc that is mined at present. The districts which have made important contributions to the zinc production of the region are the Galena, Apple River, Elizabeth, and Sand Prairie. The Galena district was the only one of these that had an output of ore in 1915. The principal mine is the old Marsden-Black Jack, first opened and worked in 1854 for lead ore. It is operated from two shafts, 200 and 250 feet deep, respectively, and is equipped with a mill having a capacity of 600 tons in 24 hours. Other important mines are the Pittsburg, Graham, Birkbeck, and the North Unity.

WISCONSIN.

PRODUCTION.

Mine production of zinc in Wisconsin in 1915.

District.	Zinc concentrates.				Recoverable. Zinc content.	
	Sphalerite.		Carbonate.			
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Benton	66,685	$2,580,675	.....	.....	19,231	$4,769,288
Cuba City	2,145	57,055	.....	.....	389	96,472
Dodgeville	654	39,800	23	$480	300	74,400
Hazel Green	24,847	865,179	.....	.....	6,973	1,729,304
Highland	118	7,879	2,034	39,643	481	119,288
Linden	7,275	287,401	.....	.....	2,430	602,640
Livingston	20,070	728,826	.....	.....	4,997	1,239,256
Mifflin	8,499	364,459	.....	.....	3,009	746,232
Mineral Point and Montfort	81	5,200	522	8,100	158	39,184
Platteville	7,966	365,596	.....	.....	3,160	783,680
Shullsburg	656	31,246	.....	.....	275	68,200
State total, 1915	138,996	5,333,316	2,579	48,223	41,403	10,267,944
1914	108,535	1,924,126	2,787	38,033	31,113	3,173,526
1913	95,540	2,053,341	3,123	30,769	30,110	3,372,320
1912	102,617	2,908,892	4,370	72,800	33,050	4,560,900
1911	93,963	1,929,123	5,035	74,143	29,720	3,388,080

Tenor of lead and zinc ore and concentrates produced in Wisconsin, 1911–1915.

	1911	1912	1913	1914	1915
Total crude ore.....short tons..	1,123,040	1,363,636	1,406,000	1,387,490	1,934,000
Total concentrates in crude ore:					
Lead.....per cent..	0.4	0.25	0.18	0.14	0.16
Zinc.....do....	8.8	7.6	7.04	8.02	7.32
Metal content in crude ore:					
Lead.....do....	.3	.2	.13	.11	.12
Zinc.....do....	3.1	2.9	2.6	2.8	2.65
Average lead content of galena concentrates...do....	76.9	76.5	74.8	73.7	73.5
Average zinc content of sphalerite concentrates.do....	34.6	38.4	38.0	35.05	36.5
Average zinc content of zinc carbonate concentrates, per cent	33.1	29.6	23.0	27.5	24.9
Average value per ton:					
Galena concentrates	$52.41	$53.57	$49.16	$42.01	$53.88
Sphalerite concentrates	$20.53	$28.34	$21.53	$17.73	$38.37
Zinc carbonate concentrates	$14.72	$16.66	$9.85	$13.65	$18.70

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RESOURCES.

The lead and zinc mines of Wisconsin are in Grant, Iowa, and Lafayette counties, and constitute the most important part of the ore deposits of the upper Mississippi Valley region. The ore deposits occur in the Galena dolomite and in the upper part of the Platteville limestone, both of Ordovician age. The ores are galena, sphalerite or zinc blende, and smithsonite or zinc carbonate, the latter locally known as "dry bone." As a lead region the district has been known from the earliest settlement days. In time the building of zinc smelters near by made a market for the zinc ores. The first zinc ore to be mined was the carbonate found in association with lead in the shallow workings above ground-water level. When all the main deposits were worked out down to water level, there was a lull in mining in the region. Though the carbonate was known to give place to zinc blende and the lead to continue on below water, it was not deemed profitable to mine when continued pumping was necessary. About 1900 the higher price of zinc led to the opening of some of the deposits below water level, since which time zinc mining has increased until Wisconsin from 1907 to 1912 stood fourth in rank among zinc-producing States, even ranking third in 1908, owing to an unusually low output by Colorado in that year. In 1913, however, Wisconsin was crowded to fifth place by the great production in Montana.

The ore bodies are found in perpendicular, horizontal, or inclined cavities known as "openings" or "crevices," "flats," and "pitches." These openings sometimes extend for considerable distances in a straight line called a "range" and may be operated at different places by different companies. When a range is once established it becomes an important guide in prospecting.

In some of the mines marcasite is so plentiful that the zinc blende concentrates are reduced to a very low grade. Owing to their nearness in specific gravity, marcasite and blende are very difficult to separate cleanly by hydraulic methods. Roasting and electromagnetic separation have been utilized in the district for many years, and especially in the last two years, to produce a marketable zinc product. The green sulphide concentrates are roasted in cylindrical roasters to drive off a little sulphur and render the iron sulphide magnetic, after which they are treated on electromagnetic separators and yield blende con-

centrates assaying from 56 to 60 per cent and pyrites tailings, some of which are salable to manufacturers of sulphuric acid. About 85 per cent of all the zinc concentrates produced in Wisconsin in 1915 were treated by electromagnetic machines. There were 10 separating plants in operation in 1915, some of them of large size, and others were building. Some of these treat only ores of one mine; others do custom work.

The mines are gathered into groups or districts, of which there were 12 that produced zinc ore in 1915. Of these, Benton-New Diggings is the most important. It had an output which was almost three times as large as that of the next district in size, and nearly one-half the total production of the State. Hazel Green and Livingston were next in order of output. The Champion mine, operated by the Wisconsin Zinc Co., made the largest individual production of zinc concentrates in the State.

IOWA.

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RESOURCES.

The lead and zinc deposits of Iowa extend along Mississippi River for nearly 80 miles in Dubuque, Clayton, and Allamakee counties. They are found in the Galena dolomite, of Ordovician age. The ore deposits of the Dubuque district occur in crevices and in caves or "openings" along these crevices. Of these openings there are five or six, the "top," "middle," and "third" being the most prolific of ore. The "flats" and "pitches" common in the Wisconsin mines have been found in only one or two mines in Iowa. The crevices have an east-to-west trend, and sometimes extend considerable distances, being mined at different places, in which case they are known as "ranges." The mining operations of recent years have generally been confined to attempts to find paying ore at deeper levels in the old ranges that are known to have produced ore in former days in the upper openings.

In early days the Dubuque mines were the most important source of lead in the United States, and in later years also the mines, especially those in the vicinity of Durango, produced considerable quantities of zinc carbonate ore. Nearly all this earlier mining was done above water level, and only within recent years has there been much attempt to mine below water level. These efforts have apparently not been profitable, as there has been no production of lead or zinc for several years and most of the companies have ceased work and forfeited their charters.

MISSOURI.

PRODUCTION.

Mine production of zinc in Missouri in 1915.

District.	Zinc concentrates.				Recoverable zinc content.	
	Sphalerite.		Silicate and carbonate.			
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Southwestern Missouri:						
Alba-Neck City	15,685	$1,131,720	125	$5,454	8,338	$2,067,824
Ash Grove-Everton	.....	.....	475	23,200	165	40,920
Aurora	892	81,178	3,993	178,802	1,849	458,552
Carl Junction	1,359	83,391	.....	.....	713	176,824
Carthage	1,153	92,992	370	21,846	759	188,232
Cave Springs	2,191	185,242	.....	.....	1,186	294,128
Duenweg-Porto Rico	27,789	2,285,151	1,507	70,161	15,291	3,792,168
Granby	7,587	511,169	10,923	586,116	7,766	1,925,968
Joplin	49,074	3,825,971	3,460	149,092	27,128	6,727,744
McDowell-Stark City	16	1,800	15	900	25	6,200
Oronogo	12,834	1,030,047	.....	.....	6,844	1,697,312
Sarcoxie-Reeds	2,002	151,563	251	12,030	1,161	287,928
Sherwood-Thoms Station	4,813	349,846	.....	.....	2,477	614,296
Spring City-Beef Branch	1,964	142,104	2,388	121,609	1,874	464,752
Springfield	1,402	92,425	.....	.....	787	195,176
Spurgeon	1,291	77,717	2	85	661	163,928
Webb City-Carterville-Prosperity	103,923	7,787,651	.....	.....	54,933	13,623,384
Wentworth	1,091	86,980	562	25,243	785	194,680
Zincite-Klondike	6,000	464,409	.....	.....	3,102	769,296
Christian, Ozark, and Taney counties	2	100	280	9,460	84	20,832
	241,068	18,381,456	24,351	1,203,998	135,928	33,710,144
Central and southeastern Missouri	43	1,064	1,061	39,460	372	92,256
State total, 1915	241,111	18,382,520	25,412	1,243,458	136,300	33,802,400
1914	189,765	7,351,726	19,648	415,185	105,994	10,811,388
1913	225,850	9,180,960	21,531	483,463	124,963	13,995,856
1912	244,986	12,346,922	22,172	641,881	136,551	18,844,038
1911	217,812	8,680,559	20,119	477,420	122,515	13,966,710

Tenor of crude lead and zinc ore and concentrates produced in southwestern Missouri, 1911–1915.[a]

	1911	1912	1913	1914	1915
SOFT GROUND.					
Total crude ore.....short tons	3,217,166	3,856,045	3,745,400	3,179,830	4,004,900
Total concentrates in crude ore...per cent	4.5	4.21	4.56	4.61	3.88
Lead.....do	.4	.34	.44	.48	.32
Zinc.....do	4.1	3.87	4.12	4.13	3.56
Metal content of crude ore.....do	2.6	2.41	2.58	2.64	2.26
Lead.....do	.3	.27	.34	.38	.25
Zinc.....do	2.3	2.14	2.24	2.26	2.01
Average lead content of galena concentrates.....per cent	79.9	79.5	78.6	78.6	79.2
Average lead content of lead carbonate concentrates.....per cent	54.7	54.8	62.2	51.3	58.1
Average zinc content of sphalerite concentrates.....per cent	58.9	58.3	57.5	57.9	57.7
Average zinc content of silicates and carbonates.....per cent	40.4	38.8	38.8	38.6	39.3
Average value per ton:					
Galena concentrates	$54.41	$54.43	$51.51	$46.16	$48.19
Lead carbonate concentrates	$35.72	$35.52	$32.66	$24.19	$32.56
Sphalerite concentrates	$40.80	$49.99	$39.93	$38.65	$72.68
Zinc silicates and carbonates	$23.76	$28.95	$22.45	$21.13	$45.00

[a] Including also the small production of zinc ores in southeastern and central Missouri.

Tenor of crude lead and zinc ore and concentrates produced in southwestern Missouri, 1911–1915—Continued.

	1911	1912	1913	1914	1915
SHEET GROUND.					
Total crude ore.....short tons..	4,944,910	5,465,100	4,303,900	3,594,170	6,501,000
Total concentrates in crude ore...per cent..	2.6	2.62	2.63	2.69	2.25
Lead.....do....	.5	.46	.47	.44	.34
Zinc.....do....	2.1	2.16	2.16	2.23	1.91
Metal content of crude ore.....do....	1.64	1.62	1.63	1.65	1.38
Lead.....do....	.4	.36	.37	.35	.25
Zinc.....do....	1.24	1.26	1.26	1.30	1.13
Average lead content of galena concentrates.....per cent..	79.9	79.6	79.0	79.3	76.4
Average zinc content of sphalerite concentrates.....per cent..	58.6	58.6	58.3	58.4	59.1
Average value per ton:					
Galena concentrates.....	$56.50	$55.83	$51.43	$47.38	$54.63
Sphalerite concentrates.....	$39.79	$50.84	$41.69	$38.86	$78.79

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RESOURCES.

The main lead and zinc producing regions of Missouri are in the southwestern and southeastern parts of the State. The former is the greatest zinc-producing area in the United States. The latter contains the district of the disseminated lead ore, which since 1907, with the exception of 1913 and 1914, has exceeded in production the Cœur d'Alene region, that for many years prior to 1908 had held first rank in the United States.

There has, however, been one important zinc producer in southeastern Missouri—the Valle mines in Jefferson County, which were opened in 1824. From that date, with the exception of the period of the Civil War, the production of lead and zinc ores from the Valle mines has been practically constant. The total output to date has been about 90,000 tons of zinc carbonate ore and concentrates and

43,000 tons of lead ore and concentrates. The tract contains more than 5,000 acres, upon which there are a great many shallow shafts operated by lessees. The ore is cleaned on hand jigs and the zinc ore is calcined before shipping.

The central Missouri district has produced considerable ore in the past, but it is operated intermittently and in the last few years has had a very small production.

The southwestern Missouri lead and zinc area includes the largest part of the Joplin region, the remaining portion lying in southeastern Kansas and in northeastern Oklahoma. The ore occurs in the Boone limestone belonging to the Mississippian series. The ore deposits are found in Jasper, Lawrence, Greene, and adjoining counties. This area produces about three-fourths of the lead and zinc ore raised in the Joplin region.

The lead ores are galena and a small quantity of lead carbonate, locally known as "dry bone"; the zinc ores are sphalerite, or zinc blende, or "jack," zinc carbonate (smithsonite), and zinc silicate (calamine), both of the latter locally called "silicate." The galena contains but a small fraction of an ounce of silver to the ton of lead concentrates and yields "soft lead." Although ordinarily it is not desilverized, yet occasionally the refineries find it advantageous to add lead ore from the Joplin region to their charges, without, however, making any record of the silver content. In this way an unknown but small quantity of silver is recovered from lead ore of southwestern Missouri. The zinc ores, sphalerite, smithsonite, and calamine, contain an appreciable quantity of cadmium.

The ore deposits of the Joplin district vary in character with the depth of mining. The shallower ores, beginning at the surface, are universally pockety or bunchy, and are found in residual clays or in "runs" in the basal breccias of the region, The breccias and the forms of the "runs" are largely, if not altogether, due to solution of the limestone strata. One form of run which is fairly numerous is the "circle" deposit, which in the popular view has come to be nearly synonymous with rich deposits. Small veins, vertical sheets, and thin crevice deposits are often met with in prospecting, but unless they develop into stringers leading into paying ore bodies are forgotten in the multitude of rich pockety deposits which the district has yielded. Fissure-vein deposits do not occur. The blanket deposits or "sheet ground" are found in the Grand Falls chert member of the Boone formation at depths varying from 125 to 275 feet, depending on the topography and the geologic structure. Below this horizon there are, in the rocks of Kinderhook age, deposits of disseminated ore. They have been worked at Springfield, Aurora, Granby, Hornet, and Cave Springs, in Missouri, and at Galena, in Kansas, and have been struck in prospect shafts or drill holes at Carterville and Joplin, in Missouri, and at Quapaw, in Oklahoma.

There are small local areas of typical sheet ground at many places, as Granby, Wentworth, Alba, Carl Junction, and elsewhere. An area of considerable size reaches from Joplin to Central City, but the typical and chief area of these deposits stretches from Oronogo through Webb City, Carterville, Prosperity, and Porto Rico to Duenweg. This area is responsible for 55 per cent of the zinc concentrates produced in southwestern Missouri in 1915. The gain in output of zinc concentrates by southwestern Missouri in 1915 over

1914 was 56,543 tons and all but 4,000 tons of this gain was due to the Oronogo-Duenweg area. When the price of zinc concentrates is low it affects particularly the sheet-ground operators, because the sheet ground is generally lean and the margin of profit very narrow. In such times, therefore, the output of the Oronogo-Duenweg belt suffers in comparison with areas in which open-ground deposits are worked. On the other hand, if lead concentrates are high in price it may offset the low price of zinc concentrates, for the lead content of the sheet-ground deposits averages nearly twice as much as that of the soft ground deposits.

The output of zinc concentrates in the Joplin region for 43 weeks of 1916 is considerably larger than it was in the same period of 1915, and the total output for 1916 will probably exceed the output for 1915 about 40,000.

Several practical tests of concentration by flotation are being made in the district, but owing to the litigation over flotation patents, no details of equipment or results are available.

KANSAS.

PRODUCTION.

Mine production of zinc in Kansas, 1915.

District.	Zinc concentrates.				Recoverable zinc content.	
	Sphalerite.		Carbonate and silicate.			
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Galena and Badger Peacock	22,128	$1,499,526	71	$2,522	11,352	$2,815,296
Lawton	5,625	424,445	.....	.....	3,013	747,224
State total, 1915	27,753	1,923,971	71	2,522	14,365	3,562,520
1914	21,812	830,176	38	623	11,284	1,150,968
1913	20,033	793,034	198	3,194	10,088	1,129,856
1912	21,258	1,005,509	125	3,152	10,633	1,467,354
1911	20,287	734,148	122	2,916	10,272	1,171,008

Tenor of lead and zinc ore and concentrates produced in Kansas, 1911–1915.

	1911	1912	1913	1914	1915
Total crude ore.....short tons	761,465	744,254	590,300	540,500	709,400
Total concentrates in crude ore:					
Lead.....per cent	0.5	0.4	0.5	0.33	0.23
Zinc.....do	2.7	2.8	3.5	4.04	3.92
Metal content of crude ore:					
Lead.....do	.4	.3	.4	.26	.17
Zinc.....do	1.5	1.6	1.9	2.32	2.25
Average lead content of galena concentrate.....do	78.9	78.3	78.2	77.9	74.9
Average lead content of lead carbonate concentrates, per cent	.....	54.5	.....	.....	.....
Average zinc content of sphalerite concentrates, per cent	56.0	55.4	55.7	57.4	57.4
Average zinc content of zinc silicate and carbonate, per cent	38.5	39.2	35.9	34.2	38.0
Average value per ton:					
Galena concentrates	$54.64	$52.88	$50.94	$42.02	$52.79
Lead carbonate concentrates	.....	40.45	.....	.....	.....
Sphalerite concentrates	36.19	47.30	39.58	$38.06	68.96
Zinc silicate and carbonate	23.90	25.30	16.13	16.40	35.52

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RESOURCES.

The lead and zinc deposits of Kansas, so far as developed, are limited to the southeastern portion of the State, in Cherokee County. They comprise the western extension of the ore deposits of the Joplin region and display the general characteristics of that area, except that here typical sheet-ground deposits have not been extensively developed, although they are being worked at the Diplomat, Empire, and Clermont mines in the Galena district. The ores are galena and lead carbonate, sphalerite or zinc blende, zinc carbonate, and zinc silicate. The mining is in general shallow, and only in the last few years have depths of 150 feet or more been reached, especially in the vicinity of Galena. This is because the ore-bearing horizons lie nearer the surface, the sheet ground being reached at 100 feet in depth in the Diplomat and Empire mines. In recent years some prospecting and mining has been done in rocks of Kinderhook age, at depths of about 300 feet, on the Hartford, Southside, Galena Lead & Zinc Co., Murphy, Robertson, and Ping lands. The results of deep drilling in 1916 indicate that there are likewise deep ores on the Hurry Up, Wyandotte, Sapp, and Page lands.

Galena is the oldest lead and zinc mining camp in the State and has always had the largest output. Badger was formerly a very productive district, but high water in Spring River in 1912 flooded the mines and they have not since been unwatered until the present year, 1916. Lawton was prospected 15 years ago but ore in quantity was not at that time developed. Since 1911 it has had a very steady creditable output. The depth of mining ranges from 90 to 132 feet, but ore bodies at lower levels are shown by drilling. Recent prospecting is extending the productive area northward and eastward to Waco.

A region in which prospecting has been active for a couple of years and in which drilling is now at the maximum lies along the Oklahoma State line from Baxter Springs for 8 miles westward and is 2½ miles wide from north to south. In this area there were at least 100 drill rigs at work at the close of 1916. A number of these were operated by the Miami Zinc Syndicate under the direction of Victor Rakowsky, who explored and developed the rich deposits in the adjoining Picher district of Oklahoma. The Miami Zinc Syndicate, which controls under lease 4,000 acres in the Kansas field, is reported to be financed by the Hayden-Stone-Jackling interests, which are also concerned in the Butte & Superior mine, and the

American Zinc, Lead & Smelting Co. The Commerce Mining & Royalty Co., which discovered and developed the original mines in the Miami district, controls 1,100 acres in Kansas; the Century Zinc Co., also a successful operator in the Picher field, controls 500 acres, which is being prospected with six drills; and J. W. Grantham has 1,200 acres under lease. Church & Mabon, who are large operators in the original Miami district, and who developed the deposits in the vicinity of Century, have recently entered the Kansas field operating as the Tri-State Mining Co., and are prospecting a large acreage. Smaller companies and individuals are also prospecting in the region. The present activity in this part of Kansas is simply the overlapping into Kansas of the progressive northerly development of mining territory from the vicinity of Commerce, Okla. The rapid leasing of territory farther north presages further extension of the prospecting campaign in that direction.

Two shafts have been sunk on the Broom Factory tract, just north of the State line and the first of the Kansas tracts to be prospected, and one shaft is being sunk on the D. S. Chubb land, two on the A. Weber land, and one on the George Stoskopf land. Shafts are about to be sunk on the A. H. Barr, L. Hocker, R. F. Hartley, and C. Ebenstein tracts, the last the scene of a recent very rich strike in drilling. Mills will be built on the Wilbur, Stoskopf, Hocker, Hartley, and Ebenstein tracts.

The ore, as developed by the shafts and the drilling, is similar in richness, depth, and type to that in the northerly development of the Miami field. In depth it ranges from 165 to 315 feet.

The Oklahoma, Kansas & Missouri Interurban Railway, which now extends to the Kansas line, is to be extended northward into Kansas and eastward to Baxter Springs. The Southwest Missouri Electric Railway Co. has announced a proposed extension from Galena, Kans., through Baxter Springs to Picher. These electric lines will aid greatly in the development of the region by giving easy connection with Miami and Joplin.

A drilling campaign has been undertaken in the territory immediately south of Columbus, Kans. The writer has elsewhere [1] commented on the occurrence of lead and zinc ores beneath the Pennsylvanian shale and at considerable depths.

The old shafts at Pleasanton, in Linn County, have been pumped out and a company is engaged in further prospecting. This region likewise has been discussed by the writer.[2]

[1] Siebenthal, C. E., Origin of the zinc and lead deposits of the Joplin region: U. S. Geol. Survey Bull. 606, pp. 202–205, 1915.
[2] Op. cit., pp. 206–208.

OKLAHOMA.

PRODUCTION.

Mine production of zinc in Oklahoma in 1915.

District.	Zinc concentrates.				Recoverable zinc content.	
	Sphalerite.		Carbonate and silicate.			
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Ottawa County:						
Miami	26,802	$1,781,821	.....	.....	13,426	$3,329,648
Peoria	.....	.....	172	$5,666	60	14,880
Quapaw	1,478	119,669	.....	.....	765	189,720
Murray County: Davis	132	9,912	.....	.....	63	15,624
State total, 1915	28,412	1,911,402	172	5,666	14,314	3,549,872
1914	28,365	926,738	8	140	13,992	1,427,184
1913	24,103	766,392	67	1,340	11,664	1,306,368
1912	12,129	494,379	92	2,550	5,769	796,122
1911	10,661	330,943	512	11,216	5,150	587,100

Tenor of lead and zinc ore and concentrates produced in Oklahoma, 1911–1915.

	1911	1912	1913	1914	1915
Total crude ore milled in Oklahoma.....short tons..	224,450	293,500	581,100	793,920	891,800
Miami district:					
Total concentrates in crude ore—					
Lead.....per cent..	2.1	2.1	1.5	1.24	1.10
Zinc.....do....	5.6	5.1	4.4	3.84	3.28
Metal content of crude ore—					
Lead.....do....	1.5	1.7	1.2	1.00	.86
Zinc.....do....	2.8	2.6	2.4	2.03	1.82
Average lead content of galena concentrates, per cent	78.3	79.6	79.8	80.0	78.9
Average zinc content of sphalerite concentrates, per cent	50.4	51.8	53.6	54.8	55.7
Average value per ton—					
Galena concentrates	$53.55	$54.42	$52.91	$47.19	$54.60
Sphalerite concentrates	$29.50	$39.80	$31.50	$32.66	$66.48
Quapaw district:					
Total concentrates in crude ore—					
Lead.....per cent..	0.4	.....	0.2	.....	0.12
Zinc.....do....	3.0	1.9	1.9	3.82	2.14
Metal content of crude ore—					
Lead.....do....	.4	.....	.13	.....	.09
Zinc.....do....	1.7	1.1	1.1	2.14	1.23
Average lead content of galena concentrates, per cent	79.3	79.5	78.4	79.0	76.8
Average zinc content of sphalerite concentrates, per cent	57.0	57.8	55.8	56.2	57.5
Average value per ton—					
Lead concentrates	$55.32	$50.00	$51.55	$50.00	$53.74
Sphalerite concentrates	$36.78	$48.36	$38.03	$34.87	$80.97

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Dunlop, J. P., Gold, silver, copper, lead, and zinc in Oklahoma: U. S. Geol. Survey Mineral Resources, 1915, pt. 1, 1916. See similar reports for 1911–1914.

Northeastern Oklahoma.—The lead and zinc mines of northeastern Oklahoma form the southwesternmost extension of the ore deposits of the Joplin region. They occur chiefly in chert breccias, but locally in limestone and sandstone breccias. The sandstones belong to the Chester group, the cherts to the Boone limestone, and the limestones to either the one or the other, both being of Mississippian age. The ores are galena, sphalerite or zinc blende, zinc carbonate, and zinc silicate.

Peoria was the site of the first lead and zinc mining in the State. The mines, though very productive for a short period, were not extensive and have had no important output since. The ores are similar to those in the soft-ground deposits of the Joplin district generally.

In the Quapaw district the ore occurs in a blanket breccia—that is, in a breccia which has a blanket form similar to the sheet ground of the Oronogo-Duenweg belt, though differing from the sheet ground in that the ore does not occur in sheets as it does in that ground. The blanket breccia differs also in horizon from the sheet ground, being 100 feet higher in the geologic column. The blanket breccia, 10 to 30 feet in thickness, is immediately above the Short Creek oolite member of the Boone formation, whereas the sheet ground of the Oronogo-Duenweg belt is in the upper portion of the Grand Falls chert member of the Boone and about 100 feet below the Short Creek oolite member. The blanket breccia is recemented with jasperoid, a black secondary chert which contains the ore, whereas in the sheet ground the chert layers are often unbroken for considerable distances and are separated by sheets of jasperoid, containing ore, which has replaced the limestone layers that originally occupied that position. Mining began soon after the discovery of ore in 1903, and in a few years many mines were opened in the blanket breccia deposits. Few of the mines had ore rich enough to be profitable at the prices of ore at that time and mining practically died away in the district. During the high prices since the early part of 1914, many of the mines have started again, and the production in 1915 was 10 times as large as it was in 1914, though less than one-third what it was in 1909.

Ore was discovered and the first shafts sunk at Miami in 1905–6, but development was not rapid until 1908. The ores are galena and sphalerite in about the proportion of one of the former to three of the latter, no oxidized ores having yet been found. The ores, as first mined in the vicinity of Commerce, occurred at a depth of 90 to 130 feet in sandstone breccias and in flint breccias lying below the sandstone. The sandstone was impregnated with a heavy oil, which, evaporating to asphalt, caused much trouble in saving the concentrates in that it balled up the ores on the jig beds and tended to float off the finer particles of ore. It also had a tendency to lower the grade of the concentrates by enveloping them in films of carbonaceous matter and so causing finely powdered marcasite and pyrite to stick to them. As the scope of mining operations widened and deepened, however, there was a noticeable rise in the grade of the concentrates. The average zinc content of the zinc concentrates sold in 1908 was about 49 per cent, whereas the average zinc content in 1915 was 55.7 per cent.

The main ore body worked at first had the form of a long straight run bearing about N. 30° W. and reaching from the Sunny Jim (Cactus) mine at the southeast to the Grey Top mine on the northwest, a distance of 1½ miles. Throughout this distance the ore body was in a sandstone breccia, with Pennsylvanian shale overlying, though at places in the run stopes were taken up in the underlying chert breccia. The width of the run varied from 75 to 150 feet and the height from 8 to 25 feet where the lower stopes were taken up. Several other ore bodies were opened to the west of this run which had their elongation parallel to it, but none of them were at all comparable to the main run in extent. As mining developments progressed, deeper drilling showed a lower run of ore under the first run and at some places a third run, and this held true also for the parallel ore bodies. The lower runs, like the upper runs, show the system of fractures parallel to the general direction of the runs. The hade of the fractures may carry the lower runs to one side or the other of the upper runs, so that they are not everywhere one directly above the other. The lower runs are, without exception, narrower than the upper runs. The ores are in chert breccias with jasperoid cement and there is little or no tar. A run with a northwest trend was discovered at Horseshoe Lake, 2 miles northwest of Miami and nearly 3 miles southwest of the mines at Commerce. This run is several hundred feet long and shows the general characteristics of the runs described above. A run, strikingly different from the foregoing runs, branches off from the long run just about one-third of its length from the north end. It bears about N. 35° E. and is approximately half a mile in length to its north end, where it curves around to the northwest. This run seems to be developed along a faulted monocline. Where it crosses the road going north from Miami the thickness of Pennsylvanian shale to the southeast is about 100 feet, but on the northwest side the shale has a thickness of about 250 feet, thus indicating a displacement of about 150 feet. Both to the northeast and to the southwest the displacement decreases, giving place to a slope of moderate dip with perhaps some step-faulting. In the run itself where mined there is much evidence of faulting. On the southeast side, the cherts and limestones of the Boone formation are sheeted, fractured, slickensided, and bent downward. On the northwest side the sandstone of Chester age pitches steeply to the northwest parallel to the hade of the disturbed area and the Pennsylvanian shale adjacent is broken up and slickensided. The top of the ore in this run was about 150 feet from the surface and levels were worked at different depths down to the present bottom level, which is at 385 feet, the deepest mining in the Joplin region.

A mile northeast of the end of the run just mentioned is another northeast run, Bluebird Run, nearly parallel with it but not quite in the same line. This run is in the sandstone beneath the shale, and there is also a deeper run in the chert beneath. North of this run to the Kansas line and east of it to Quapaw numerous ore bodies have been discovered, and many rich deposits are being mined in the vicinity of Cardin, Century, and Picher, but no long, straight runs have been developed. In the vicinity of Commerce the Chester rocks are fairly regular in distribution, and the evidences of erosion and solution are not pronounced. Toward the northeast the evi-

dence of pre-Pennsylvanian erosion grows stronger, and not far north of Quapaw the Chester rocks disappear, except where they are preserved in sink holes and other depressions due to solution. It is to be expected, therefore, that the runs which are developed in the field west and northwest of Quapaw to the Kansas line will not exhibit the long, straight forms but will be more irregular and more of the nature of runs in the open ground.

In the latter part of 1916 there were 26 mills in the vicinity of Commerce and 25 mills in the newer field to the northeast, and there were also 19 additional mills planned for erection before the end of the year.

Arbuckle Mountain region.—In the southern part of Oklahoma prospecting and some mining for lead and zinc has been prosecuted in Murray County, 8 miles southwest of Davis, near the northwest end of the Arbuckle Mountains. The Arbuckle Mountains consist of a core of pre-Cambrian granite and diabase overlain by the Reagan sandstone, a basal conglomerate formation of Upper Cambrian age, and that in turn by the Arbuckle limestone of Cambrian and Ordovician age, followed in order by the other formations of the Paleozoic in that province. The whole uplift is greatly faulted and, especially in the mining district southwest of Davis, is sharply folded. The ore deposits in the Davis area are found in the dolomitic Arbuckle limestone, generally in clay-filled solution channels. The zinc ore occurs as a carbonate from the surface to a depth of 5 to 8 feet. Below this level the zinc is in the form of the sulphide.[1]

Nearly all the ore has been taken from shallow workings, and none of the mining properties have been large producers. The first ores were mined in 1909, and small shipments were made during the next three years and also in 1915. The total recorded production of the district, including 1915, is 558 tons of zinc carbonate and 407 tons of sphalerite.

ARKANSAS.

PRODUCTION.

Mine production of zinc in Arkansas, 1911–1915.

District.	Zinc concentrates.				Recoverable zinc content.	
	Sphalerite.		Silicate and carbonate.			
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
Northern Arkansas, 1915	606	$41,341	7,925	$408,079	3,209	$795,832
1914	743	19,406	1,143	25,187	608	62,016
1913	594	16,916	680	15,050	478	53,536
1912	1,419	56,235	462	11,231	748	103,224
1911	1,407	40,425	183	4,239	664	75,696

[1] Snider, L. C., Preliminary report on the lead and zinc of Oklahoma: Oklahoma Geol. Survey Bull. 9, pp. 86–90, 1912.

Tenor of lead and zinc ore and concentrates produced in Arkansas in 1911–1915.

	1911	1912	1913	1914	1915
Total crude ore.....short tons..	24,925	32,755	13,000	20,000	110,000
Total concentrates in crude ore:					
Lead.....per cent..	0.3	0.1	0.17	0.26	0.07
Zinc.....do....	6.4	5.7	9.8	9.4	7.76
Metal content of crude ore:					
Lead.....do....	.2	.1	.14	.2	.06
Zinc.....do....	3.2	2.7	4.3	3.9	3.25
Average lead content of galena concentrates..do....	80.0	79.5	78.3	78.9	79.8
Average zinc content of sphalerite concentrates,[a] per cent.....	50.2	49.0	48.0	44.7	59.6
Average zinc content of zinc silicate and carbonate, per cent.....	39.1	38.0	40.6	40.0	40.6
Average value per ton:					
Galena concentrates.....	$54.01	$55.90	$51.24	$46.31	$62.80
Sphalerite concentrates.....	28.73	39.63	28.48	26.12	68.21
Zinc silicate and carbonate.....	23.16	24.31	22.13	22.04	51.49

[a] Includes some mixed carbonate and sphalerite prior to 1915.

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RESOURCES.

Lead and zinc deposits have been known in Arkansas for many years, but present development dates from about 1899. The mines are principally in Marion County and in the adjoining portions of Searcy, Newton, and Boone counties, though there are also numerous mines and prospects in Baxter, Izard, Sharp, Lawrence, and other counties to the east, and one deposit was worked for a short time in Washington County on the extreme western border of the State.

The ores are galena, sphalerite, and smithsonite, but lead is only about one twenty-fifth as plentiful as zinc. The sphalerite is generally very high grade, and the concentrates when clean range well above the price basis, 60 per cent metallic zinc content, and hence command a premium. They are in demand also on account of their general freedom from lead. The sphalerite and smithsonite are shown by analysis to contain appreciable quantities of cadmium, a yellow variety of smithsonite, known locally as "turkey fat," showing as high as 0.8 per cent of cadmium.

The ore bodies occur in fissures, in fault breccias, and in solution breccias. The ore deposits are for the most part found in limestone of early Ordovician age, but some also are found in the Boone limestone, of Mississippian age.

The output in 1915 was five times as large as in the preceding year, and the number of producing mines and prospects increased from about 30 to nearly 100. The increase was altogether in carbonate ore, as there was a decrease in the output of sphalerite concentrates. This was the result of the great demand for carbonate ores by new smelters which had completed their zinc furnaces before their acid

plants and could use carbonate ore but not sulphide ore. The output for 1916 gives promise of being four or five times as large as it was in 1915. The camps or districts which were most active were Zinc, in Boone County, and Buffalo, Dodd City, Kingdon Springs, and Rush, in Marion County. The Rush district produced about one-half the total output of the State. An interesting feature of the year was the reopening by the Lavender Mining & Milling Co. of the Hoppe mine in Lawrence County and the Pearce mine in Sharp County, both previously operated by the Independence Mining Co. in 1858 and even earlier. A zinc smelter erected by this company was unsuccessful. These mines and others were taken over in 1867 by the American Zinc Co., which in 1872 completed a zinc smelter using charcoal for reduction purposes. The smelter ran only a few months.

A branch railroad to connect Rush and Yellville is under construction and on completion will greatly facilitate production in the Rush district. Zinc smelters were built at Fort Smith and Van Buren, and have already entered the northern Arkansas field for ores

TEXAS.

The zinc production of Texas has at no time been large. The recoverable zinc content of ores mined in 1915 was 15 tons, 108 tons in 1914, 326 tons in 1913, and 119 tons in 1912. There was no production in 1911 nor for several years before that time.

The zinc and silver-lead mines of Texas are chiefly in the trans-Pecos or western part of Texas. In the central Texas region[1] there are lead prospects on Silver Creek, near Bluffton, Burnet County, and zinc-fluorspar prospects on Spring Creek, 7 miles west of Burnet. In the western part of Texas, near Alpine in Brewster County, the Bird mine has shipped some argentiferous lead ore, and in the adjoining Presidio County the Shafter mine is the most important silver-lead mine of the State. In the Quitman Mountains of El Paso County the Bonanza and Alice Ray mines have produced silver-lead-zinc ores.[2] The Bonanza mine, about 2 miles from Lasater station, on the Southern Pacific Railroad, has made regular shipments of zinc ore for several years and has produced all the zinc mined in the State since 1910. The ore consists of lead and zinc sulphides, which are hand sorted, the zinc ores averaging from 40 to 45 per cent zinc. The mine is opened to a depth of 300 feet. In the same county the Davis & Robinson mines, near Torbert, are reported to have made shipments of zinc ore. The Buck mine in Culberson County has been described by Udden.[3] This prospect is in the hills 12 miles north of Boracho station on the Texas & Pacific Railway. The ore, which consists of zinc carbonate and sulphide, is found in veins, stringers, and cavernous openings in limestone and is associated with calcite as a gangue mineral. Shipments of ore containing 34 per cent zinc have been made. The openings consist of small open pits, a short tunnel, a slope 40 feet deep, and 2 shafts, 25 and 40 feet deep.

[1] Paige, Sydney, U. S. Geol. Survey Geol. Atlas, Llano-Burnet folio (No. 183), 1912.
[2] Von Streeruwitz, W., Geology of trans-Pecos Texas: Texas Geol. Survey First Ann. Rept., pp. 221–224, 1890.
[3] Udden, J. A., The Buck zinc prospect near Boracho, Texas: Min. and Sci. Press, vol. 108, pp. 493–494, 1914.

NEW MEXICO.

PRODUCTION.

Mine production of zinc in New Mexico in 1915, in short tons.

County.	From zinc and zinc-lead ore.	From dry or siliceous ore.	Total recoverable zinc.
Grant and Luna	3,472		3,472
Santa Fe		7	7
Sierra	4		4
Socorro	9,219		9,219
State total, 1915	12,695	7	12,702
1914	9,202		9,202
1913	8,262		8,262
1912	6,783		6,783
1911	5,119		5,119

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RESOURCES.[1]

Sixteen mines in New Mexico produced zinc in 1915, 1 from siliceous ore and 15 from zinc and zinc-lead ores. The siliceous crude ore carrying zinc amounted to 700 tons and the zinc and zinc-lead ores to 71,661 tons, a total of 72,361 tons of zinc-bearing crude ores.

The zinc deposits of New Mexico are chiefly in the southwestern part of the State, in Socorro, Sierra, Grant, and Luna counties, but some zinc ore is found in Santa Fe County.

The zinc deposits of Santa Fe County are in the Cerrillos district. The principal mines were the Cash Entry and the Central, which in 1908 were respectively 650 and 500 feet in depth. The ores are lead and zinc sulphides below water level and residual galena and zinc carbonate above water level. The production in 1915 came from the Tom Payne mine, on the north side of the Cerrillos Hills.

The principal mines of the Magdalena district, in Socorro County, are in the Magdalena Range and near the mining town of Kelly. The range consists of a pre-Cambrian basement complex upon which rests a series of Carboniferous limestones, quartzites, and shales. These rocks, dipping about 35° W., are flanked on the west, from Kelly southward, by Tertiary andesite and rhyolite and are cut by a stock of monzonite, which is closely associated genetically with the ore deposits.

The ore deposits include veins and bed replacements, the latter by far the more important. They lie in or close by fault fissures, most

[1] For notes on the Hanover district the writer is indebted to A. C. Spencer, and for notes on the Magdalena district to G. F. Loughlin, both of the United States Geological Survey.

of which are considered to be due to the thrusting action of the intrusion of monzonite. The deposits vary in mineral composition with the distance from the monzonite contact. Those nearest the contact lie along fissures in moderately metamorphosed limestone and consist of pyrite, magnetite, and specularite, with local shoots of zinc blende. The gangue contains tremolite and a chloritic material, and also quartz and subordinate barite. Where downward circulating waters have been effective the pyritic portions have been sufficiently enriched in copper (from 5 to 8 per cent) to become ore, as in the Waldo mine of the Ozark Mining & Smelting Co.

Farther from the contact the magnetite and the silicate gangue materials disappear and galena appears, though subordinate to zinc blende. This class of ore is found in the southern part of the Waldo and Graphic mines and in the Kelly mines of the Empire Zinc Co. It is shipped as zinc-lead sulphide ore and contains a few ounces of silver to the ton. Where the ore has been subject to oxidation, the zinc has been deposited as carbonate beneath or down dip from the original shoot, which is mined for lead and silver.

South of the Kelly mine barite is an important gangue mineral, but specularite is not found in conspicuous quantity. Fluorite is locally present. The primary ore is zinc-lead, with low silver content as a rule. The shipping ore forms local shoots in silicified limestone, which is a practically continuous replacement deposit in the upper Kelly limestone and extends along the zone of mineralized faults, to and beyond the southern boundary of the district. In this vicinity veins of similar mineral composition have been prospected in andesite, but thus far have yielded only small quantities of ore of milling grade.

During 1915 shipments of lead and zinc ores and concentrates were made from the Kelly, Waldo, Ambrosia, Germany, and Juanita mines. The 150-ton flotation mill of the Ozark Mining & Smelting Co. was burned in 1916, and work was begun on a new one. The Empire Zinc Co.'s magnetic separation and wet-concentration mill, idle in 1915, was operated in 1916.

The zinc ores of the Pinos Altos district of Grant County are of two types, replacement deposits and veins in granodiorite. The replacement deposits occur in a small area of limestone of Pennsylvanian age, which is surrounded and intruded by igneous rocks. The ore, which is believed to be genetically connected with the intrusive rocks, replaces two beds of the limestone in a fairly regular manner. The two layers of ore are separated by 4 to 15 feet of limestone, the upper layer being about 12 feet thick and the lower one about 25 feet thick. The ore consists of sphalerite, chalcopyrite, and pyrite, in a quartz and ferriferous carbonate gangue. The sphalerite is well crystallized and at places is arranged in bands. The principal mines are in the Cleveland group belonging to the Empire Zinc Co., but ore bodies of the same type are known on the Stevens claims just west. The Empire Zinc Co.'s magnetic separation mill was completed in November, 1915, and has had an important output. It is reported that flotation equipment is being added to treat the tailings from the mill.

The vein deposits are just southwest of Pinos Altos and cut both granodiorite and diorite porphyry. The veins are steep and have a general northeast trend. The width ranges from a few inches to

6 feet. The veins are due to the filling of open fissures and they display well-marked crustification. The filling consists of pyrite and chalcopyrite in a gangue of quartz, and calcite, locally with barite and rhodocrosite. In many of the veins sphalerite and galena are also present. The sulphides carry some gold and silver. Most of the mines were originally worked for gold, and some very rich gold pockets were mined in 1914. In 1915 shipments were made from the Langston and Pacific mines of the Pinos Altos Mining & Milling Co., which built a 50-ton mill equipped with Huff electrostatic machines. A zinc-barite concentrate from the Huff machines is treated with a dilute solution of copper sulphate which precipitates a thin film of copper sulphide on the sphalerite and renders it a conductor so that it can be easily separated from the barite by re-treatment on the electrostatic machines.

In the Hanover district the zinc mines that have been the principal producers are those of the Empire Zinc Co. The deposits, which have been worked at intervals since about 1894, occur in limestone outside of and adjacent to a zone of intense metamorphism bordering a stock of granodiorite. This ore, chiefly smithsonite, was found as replacement bodies, whose dimensions were governed by the arrangement of fractures. Where replacement was less extensive the ore formed along the fissures and inclosed "horses" of limestone of considerable size. Until 1916 only oxidized ores were mined. During 1916 a magnetic concentrating plant was completed and put into operation on sulphide ore from the lower levels. This mill produces concentrates from ores in which the zinc mineral is ferruginous sphalerite. The gangue minerals include manganiferous calcite and pyroxene, garnet, epidote, and pyrite. Galena is present in small quantity only. The sulphide ore bodies have been developed by means of tunnels and shafts, though no shafts have been carried to any great depth. These workings have explored only a small part of the outer metamorphic zone. The work so far done suggests that the zinc sulphide shoots lie parallel to the somewhat irregular trend of the metamorphic zone and have their elongation in the same manner. Among the zinc producers in 1915 and 1916, in addition to the mines of the Empire Zinc Co., were the Mountain Home group and the Welsh group. The Republic Mining & Milling Co. is reported to have opened in 1916 a large body of zinc ore in a new shaft at a depth of 100 feet. Many shafts, sunk in prospecting for gold and copper in the Hanover-Santa Rita region, show notable quantities of zinc blende.

The Steeple Rock district is in the northwestern part of Grant County in a region of lavas and diorite porphyry. Quartz is the predominant gangue mineral of the ore deposits. The sulphide ore minerals in the order of their abundance are pyrite, zinc blende, chalcopyrite, and galena, disseminated in grains through the gangue, the zinc blende showing a tendency to aggregate in streaks. The Carlisle mines were worked for gold in the eighties and nineties. In 1915 the mines were reopened to the 627-foot level and shipments of gold, silver, and lead ores were made. A mill with flotation equipment was erected in 1916 and some zinc concentrates were produced. Large ore reserves are claimed.

The Cooks Peak district in 1915 produced considerable zinc ore, and production continued in 1916. The shippers were the Faywood, Desdemona, Othello, and Summit mines. The deposits are

replacements of limestone in a silicified zone beneath broad arches in overlying shales. The ore minerals are galena and sphalerite, with their oxidation products, zinc and lead carbonates.

The Florida Mountain district had one producer of zinc in 1915 and 1916, the Mahoney property, which shipped zinc carbonate ore.

The Tres Hermanas district in 1915 and 1916 had an output of zinc carbonate from two mines, the Contention and the mines of the Deming Zinc Mines Co. The Contention mine is opened by an incline shaft, which slopes 30° and follows the dip of the inclosing limestone. The shaft was 150 feet deep in 1908. The other property is opened by shallow inclines and cuts. The first ore mined was galena, and the zinc carbonates and silicate ores were left behind. In 1904 these ores were recognized, and in 1905 a considerable quantity of them was shipped. The ores occur in limestone and are due to contact metamorphism. The association of zinc minerals in the Tres Hermanas is noteworthy in that willemite, an uncommon silicate of zinc, is the most plentiful ore mined, being followed by calamine, the ordinary silicate of zinc, and smithsonite and hydrozincite, both carbonates of zinc.

In the Hachita district, Grant County, 8 miles southwest of Hachita station, is the American group of eight claims, said to have yielded, years ago, a large quantity of high-grade silver ore. This came from above water level, which is reached at a depth of 75 feet; but below water level the ore changed to mixed lead and zinc sulphides which could not be successfully separated at that time. Hundreds of tons of zinc and lead ore are reported to be lying on the dump.

In the Organ district, in Dona Ana County, the Merrimac claim was developed several years ago to a depth of 200 feet and showed zinc blende with some chalcopyrite in a garnetiferous limestone. It is reported that this property was reopened in 1916, the result being the discovery of a large body of zinc ore.

COLORADO.

PRODUCTION.

Mine production of zinc in Colorado in 1915, in short tons.

County.	From zinc ore.	From lead-zinc ore.	From siliceous ore.	Total recoverable zinc.
Chaffee	648	62	1,628	2,338
Clear Creek	28	725	.....	753
Custer	15	.....	.....	15
Dolores	9	9	.....	18
Eagle	341	5,230	.....	5,571
Fremont	114	.....	.....	114
Gilpin	.....	.....	5	5
Gunnison	726	149	.....	875
Lake	17,363	18,884	.....	36,247
Mineral	.....	43	.....	43
Ouray	.....	4	.....	4
Park	236	.....	.....	236
Pitkin	50	57	.....	107
Saguache	3	19	.....	22
San Juan	.....	146	984	1,130
San Miguel	.....	28	492	520
Summit	51	4,248	.....	4,299
State total, 1915	19,584	29,603	3,110	52,297
1914	28,147	18,766	1,474	48,387
1913	33,153	23,177	3,343	59,673
1912	42,495	21,339	2,277	66,111
1911	25,695	19,112	2,497	47,304

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RESOURCES.

Some zinc ore was produced in Colorado as early as 1885, but the zinc output of the State first became considerable in 1892. In 1899 the production became important and rose rapidly until 1912, when the maximum output was made. According to C. W. Henderson the recoverable zinc content of ore produced from 1885 to 1915, inclusive, amounted to 615,000 short tons.

The zinc deposits of Colorado are chiefly in the sulphide belt, which trends northeastward from the Rico district in the San Juan region to the Central district in Boulder County.

In the Leadville region the limestones, quartzites, and shales are extensively faulted and are intruded by dikes and sills of acidic porphyry. The most important deposits of ore are found in Carboniferous limestone, lying against the "white porphyry" above and extending irregularly into the limestone below. There are also deposits near other porphyry sheets, as well as veins and fault breccia deposits. The chief ore mineral is argentiferous galena, with its oxidized products—carbonate of lead and chloride of silver. Zinc carbonate and zinc silicate are found below the lead carbonate stopes, the zinc having been leached out of the sulphide ore body when it was oxidized and carried downward into the limestone, which it replaced. In depth the ores consist of fairly equal quantities of galena, sphalerite, and pyrite, with some chalcopyrite and other minerals.

The Leadville district was first opened as gold placer diggings in 1860, and through the finding of pieces of silver ore in the wash the rich silver-bearing lead carbonate ores were discovered in 1875.

Worked downward, the carbonate ore led to the mixed sulphide ore bodies which, until recently, furnished the main part of the output of the district. The zinc carbonate and silicate ores which lie adjacent to and below the lead carbonate deposits were passed by, in part because zinc was undesirable and in part because they were not recognized, being mistaken for ferruginous limestone. Small lots of zinc carbonate and silicate from the Robert E. Lee mine had been shipped to mineral dealers for many years, and the operators of the mine in 1899 recognized the zinc ores but avoided them, as they were of too low grade to sell at that time. In the early part of 1908 better deposits were discovered, and in 1909 about 250 tons, averaging 21 per cent zinc, was mined. The two or three carloads shipped at that time were not profitable, nor were several carloads of zinc carbonate ore reported to have been shipped from the Penrose mine.[1] In May, 1910, zinc carbonate ore of shipping grade was discovered in the old upper workings of the May Queen mine. Similar ore was soon discovered in the upper abandoned drifts of the Wolftone, Maid of Erin, Henrietta, Morning Star, and other mines, and by the end of the year 8,059 tons of zinc carbonate and silicate ore had been shipped. Further discoveries and increased activity in 1911 brought the output of zinc carbonate ore up to 83,905 tons, which was surpassed in 1912 by an output of 142,787 tons, the maximum production to date. Since 1912 the output of zinc carbonate ore has decreased each year until in 1915 it was 82,592 tons, the total output for 1910–1915, inclusive, being 566,979 tons. The average grade of the zinc carbonate ore has gradually dropped from an assay zinc content of 31 per cent in 1911 to 22.5 per cent in 1915. The local zinc oxide plant buys zinc carbonate assaying as low as 14 per cent zinc. Three extensive pumping undertakings have recently made available the lower workings of an extensive and rich territory long flooded. The Down Town Mines Co. in 1916 unwatered about 400 acres of Carbonate Hill, partly underlying the upper portion of the city of Leadville. The United States Smelting, Refining & Mining Co. recently unwatered a large tract on Fryer Hill, and the Empire Zinc Co. and the Western Mining Co. are cooperating in unwatering the deeper workings on the upper part of Carbonate Hill. These operations will result in additions to the output of zinc carbonate ore and will greatly increase the production of lead and zinc sulphide ore.

The Red Cliff (Battle Mountain) district was second in production of zinc in the State in 1915, with an output of over 5,571 tons of recoverable zinc. The mines having the largest production are the Iron Mask, the Bleak House, and the Black Iron. The first-mentioned mine was taken over by the Empire Zinc Co. in July, 1915, and the Black Iron mine was acquired in 1916. The crude ore averages 1 to 5 per cent lead, 17 per cent zinc, and 30 per cent iron. The mill has roasting and magnetic separation equipment. According to Means, the geology of the region and the conditions of ore deposition are similar to those at Leadville. The ore deposits occur in fissure veins in the basal granite and as replacements of quartzite and of limestone, the latter especially in the vicinity of porphyry sheets.

The Breckenridge district was third in production of zinc, with a large increase in 1915. The principal part of the production came

[1] History of the zinc industry in Colorado: Min. Sci., vol. 64, p. 85, 1911.

from the Wellington mine, which has a 110-ton concentrating mill equipped with flotation apparatus and also with roasting and magnetic separation machinery. According to published reports of sales between December 1, 1914, and October 1, 1915, the sales of zinc concentrate for 1915 must have exceeded $500,000 in value. The ores occur in veins in monzonite porphyry, the veins reaching a maximum width of 15 feet. The ore consists of galena, sphalerite, and pyrite in different proportions, and contains some gold and silver.

The Kokomo or Tenmile district had a small output of zinc in 1915, though it formerly had a large production. The 300-ton Robinson mill, which formerly employed roast-magnetic separation, was adapted to a system of preferential flotation and is operated as a custom mill. The ore is subjected to a mild roast which surficially oxidizes the galena and pyrite and makes them unamenable to flotation; the zinc blende is then removed by flotation. The galena and pyrite are separated from the gangue by table concentration. Numerous mines with complex ores are being reopened and are sending their ores to this mill. The production for 1916 should show a good increase.

The Chalk Creek district is also an important producer, the output of which is made largely by the Mary Murphy mine. This mine produced 4,700 tons of zinc concentrates in 1915, which sold for $328,000. The mine has a 175-ton mill equipped with flotation apparatus and electrostatic separation machinery. The ore body is a vein in quartz monzonite and has been developed to a depth of over 1,900 feet. The ore minerals in order of quantity are zinc blende, galena, pyrite, and chalcopyrite, with cerusite, anglesite, and malachite in the oxidized zone. The gold and silver content of the ores decreases in quantity with depth.

The Monarch district, but a few miles distant from the Chalk Creek district, had an increased production of zinc in 1915 notwithstanding that the largest mine, the Madonna, was closed during the last half of the year by a caved shaft. The chief ore bodies are fillings in fault fissures in limestone, but there are also replacement deposits. The oxidation zone has a depth of 800 feet at several mines. The ore minerals are galena, sphalerite, pyrite, cerusite, and smithsonite, with associated gold and silver. Cerusite has formed the chief product of the mines, with smithsonite next in quantity.

The Eureka district produced 1,125 tons of recoverable zinc in 1915. The Sunnyside mine is one of the largest producers. The Sunnyside lode is from 20 to 50 feet wide, which, with the No Name lode and several other veins, makes a very large body of low-grade ore. The Sunnyside mine was worked as a prospect in 1875, but early operations were concerned with rich gold ore. The ore minerals are galena, zinc blende, chalcopyrite, pyrite, tetrahedrite, and free gold, in a gangue of quartz and rhodonite and a little fluorite. The Sunnyside mills are equipped with 40 stamps, a Huff electrostatic separating plant, and flotation machinery. The Gold King mill is also equipped with flotation cells.

In the Montezuma district a 50-ton concentration plant with flotation equipment was completed late in 1915 by the Montezuma Mines & Milling Co. and made a promising output of zinc concentrates. Large bodies of mixed zinc-lead sulphides occur in the extensive vein

system of the region. The early production of the district was of rich silver ore.

In the Upper San Miguel (Telluride) district, the Black Bear mine made a good production of zinc-lead-gold ore. Both lead and zinc concentrates were produced in 1915, and the mine was actively worked in 1916 and an increased output resulted.

In the Elk Mountain district, the Doctor mine has shipped a large quantity of zinc carbonate since June, 1915. Among other districts which made a promising output of zinc ore were the Tin Cup, Turret, Iris, Rico, Horseshoe, Aspen, and Georgetown districts.

SOUTH DAKOTA.

South Dakota has never produced any zinc ore, although small shipments of lead ore have been made regularly for many years. It is reported that shipments of argentiferous lead-zinc ores have been made lately from the Merritt mine, in the Galena district.

Formerly there was a lead smelter in the vicinity of Galena, Lawrence County, and several mines were producing heavily.[1] Considerable development work was done in 1911 and 1912 on the property of the Deadwood Lead & Zinc Co., in Spruce Gulch, near Deadwood, which is said to have shown good bodies of the mixed sulphides, galena, blende, and pyrite, carrying some gold and silver. Trial shipments were made to determine a suitable method of separation. The attempt was apparently unsuccessful, as no activity has been reported for several years.

MONTANA.

PRODUCTION.

Mine production of zinc in Montana in 1915, in short tons.

County.	From dry or siliceous ore.	From zinc ore.	From lead-zinc ore.	Total recoverable zinc.
Beaverhead			16	16
Jefferson			10	10
Lewis and Clark		7		7
Mineral			216	216
Ravalli			67	67
Silver Bow	26	23,549	69,682	93,257
State total, 1915	26	23,556	69,991	93,573
1914		966	54,824	55,790
1913		376	43,961	44,337
1912		13,432	27	13,549
1911		21,867	38	21,905

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[1] Irving, J. D., Economic resources of the Black Hills, with contributions by S. F. Emmons and T. A. Jaggar: U. S. Geol. Survey Prof. Paper 26, p. 169, 1904.

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RESOURCES.

In Montana 12 mines produced zinc in 1915, 1 from siliceous ore, 4 from zinc ore, and 7 from lead-zinc ore. The siliceous crude ore carrying zinc amounted to 830 tons, the zinc ores to 178,573 tons, and the lead-zinc ores to 580,475 tons, a total of 759,878 tons of zinc-bearing crude ores.

The production of zinc in Montana began in 1905 in the Butte district with an output of concentrates containing 780 tons of recoverable zinc, largely from the mill of the Montana Zinc Co. This was increased to 3,290 tons in 1906, but during that year the mill was burned and the output for 1907 was small. Other mills were built and the production has continued to increase. The total recoverable zinc output of the State, 1905–1915 inclusive, is 255,000 tons.

The Butte district, formerly an important producer of gold and silver, and for many years the most important producer of copper in the country, is now near second place in zinc production and bids fair to take first place in a few years. The ores occur as replacement veins in quartz monzonite, aplite, and porphyry phases of the great Boulder batholith. The principal copper veins are in the area occupied by the northern part of the city of Butte and reach from Centerville to Meaderville. North, west, and south of this area are the silver-zinc veins. On the border ground between the two areas, the mines carry silver-zinc ores in their upper workings, and copper ores in the deeper workings. According to Bard and Gidel,[1] zinc constitutes approximately 1 per cent of the unoxidized vein material of the district, copper 0.75 per cent, and lead 0.20 per cent. The present production of zinc is from mines formerly operated as silver producers which were abandoned on account of the decline in the price of silver; some of them, possibly owing to the presence of too much zinc. A number of old copper mines, however, are known to contain zinc and will probably be opened as zinc mines in the near future.

The present position of Butte as a zinc producer is due to the successful application of flotation concentration to the zinc ores of the Black Rock mine by the Butte & Superior Mining Co. This company operates the Black Rock mine on the Rainbow lode and owns 165 acres adjoining in the northeastern part of the Butte district. Formerly a silver producer, the Black Rock mine was reopened

[1] Bard, D. C., and Gidel, M. H., Mineral associations at Butte, Mont.: Am. Inst. Min. Eng. Trans., vol. 46, p. 123, 1914.

in 1907 in the hope of finding copper ore. Developments proved that instead of the upper deposits of silver ore being underlain by copper ores the principal metal in the deeper ore was zinc. The zinc ores were worked at a loss for several years with a mill recovery at first of 55 per cent by wet concentration, but the mill was enlarged and improved and flotation equipment was added, all of which has resulted in a zinc recovery of 93 to 95 per cent for the last two years and in large profits. The mill treated 522,300 tons of ore in 1915, from which 152,897 tons of zinc concentrates, averaging over 53.6 per cent zinc, was produced and 5,274 tons of lead concentrates, averaging 37.8 per cent lead, both lead and zinc concentrates containing some gold, silver, and copper, which are recoverable. Late in 1916 large additions to the mill were decided upon. Though operations were stopped for 11 days in August by an accident to the shaft, the total ore treated during 1916 will show an increase of approximately 20 per cent over that in 1915. In addition to the original Black Rock shaft, 1,900 feet in depth, a new hoisting shaft and a supply shaft were sunk in 1916 to a depth of 1,500 feet. They will be equipped with hoisting machinery suitable for operation to a depth of 5,000 feet. Development work on the 1,700 and 1,800 foot levels from the Black Rock shaft are reported to show ore bodies of normal size and grade, as compared with those in higher levels, where the ore bodies range from narrow stringers up to 100 feet in width. The mine is opened by levels at each hundred feet from 900 to 1,800 feet. A recently completed crosscut on the 1,200-foot level to the Col. Sellers shaft and beyond to the Mastodon vein is said to have opened promising zinc-ore veins. The Elm Orlu mine, owned by W. A. Clark & Son, is next to the Black Rock mine in importance as a zinc producer, and lies adjacent to it. The Elm Orlu tract covers part of the Rainbow lode and several other veins containing both copper ore and large bodies of zinc ore. The mine is developed by a 1,400-foot shaft, which will probably soon be deepened to 2,200 feet, and by several miles of workings principally below the 900-foot level. The output of the mine is treated by the concentrator of the Timber Butte Milling Co., which is owned by the Clark interests, situated on Timber Butte, south of the city of Butte. The mill is equipped with flotation machinery and has a treatment capacity of 700 tons daily, which is being enlarged to 1,000 tons. The recovery is said to be over 93 per cent and the zinc concentrates to average 52 per cent zinc. The Clark interests are reported to be building a 1,500-ton plant, using the flotation process to treat the large piles of zinciferous tailings estimated to contain more than 1,000,000 tons from the old Butte Reduction Works. The same interests are reported to be developing the Eveline mine, near Walkerville. A drift is being driven on the 300-foot level to a vein of high-grade zinc-silver ore.

The Anaconda Copper Mining Co., having developed a successful electrolytic process for the reduction of zinc ores, has likewise become extensively interested in zinc properties in the Butte district. The following mines, most of them formerly worked for silver ore, have either been purchased wholly or partly or have been optioned by the company: Alice, Lexington, Poulin, Emma, Nettie, East Colusa, East Grayrock, Badger State, Pilot Butte, Bonanza, and others.

The Alice mine, a famous silver producer between 1880 and 1893, is on the Rainbow lode, as is also the Magna Charta, one of the claims of the Alice group. The Alice mine is developed by a 1,500-foot shaft, which has been recently retimbered. Large bodies of zinc ore are said to have been blocked out by previous operations. The lode is reported to reach 200 feet in width and the ore to carry 1½ per cent copper and 18 per cent zinc. The Alice mine was one of the first of the old silver mines to be worked for its zinc ores. The Montana Zinc Co. in 1904 and 1905 operated the Alice mill, which had been remodeled and equipped with electrostatic separation machines. Ores from the Lexington and other mines were also treated. The mill was destroyed by fire in 1906.

The Lexington mine lies near the Alice, and is connected with it on the 600-foot level. It is opened by a 1,450-foot shaft and about a mile of workings. About 30,000 tons of ore gave an average assay of 1.2 per cent copper, 3.5 per cent lead, 18 per cent zinc, and 5.5 ounces silver and $1.60 gold per ton, and this is believed by Weed to be a fair average for 400,000 tons blocked out in the lower levels. The ore bodies are large, with invisible impregnations of chalcopyrite and pyrite, which make the ore difficult to treat by ordinary methods but easily amenable to leaching and electrolytic deposition. The property comprises 32 acres and is at present one of the main sources of supply of the new electrolytic plant of the Anaconda Co.

The Poulin mine near Centerville has a 1,200-foot shaft, but is operated through the 1,500-foot Buffalo shaft. It makes a good output of zinc ore.

The Emma mine, last operated in 1906 by the Butte Copper & Zinc Co., is now being actively developed by the Anaconda Co. The shaft has a depth of 800 feet, but will be sunk to 1,600 feet to connect with a crosscut at that level from the Gagnon, which was completed in 1916. The vein is said to be 21 feet wide on the 200-foot level, and on the 400-foot level where the vein is 30 feet wide there are over 1,000 feet of workings. On the 800-foot level the vein is reported to be 125 feet wide, with 20 feet of 18 per cent zinc ore. Recent developments have shown substantial ore bodies on this level. Several thousand tons of ore shipped in the later part of 1916 are reported to average 15 to 19 per cent zinc, 7 per cent lead, and 7 ounces silver. The daily shipments average about 150 tons.

The Nettie mine is about 2 miles west of Butte, The shaft is 500 feet deep and there are about three-fourths of a mile of workings at that level and several miles at higher levels. Regular shipments of zinc ores are being made, and it is reported that 40,000 tons of silver-zinc ore has been blocked out. The shaft is being sunk to 1,500 feet. It is possible that zinc ores may be found in the Bluebird mine and also in the Hibernia prospect in this region.

The East Colusa mine, at Meaderville, was formerly a copper producer of the Anaconda Co., although there has always been zinc in the ore, and it will now be operated for the zinc. The mine is developed by a 900-foot shaft, with levels from 300 to 700 feet. The vein is about 60 feet in width and the output of zinc ore is about 200 tons daily.

The Badger State mine is in the northeastern part of the district not far from the Elm Orlu and Black Rock mines. The shaft is

2,200 feet in depth and there are 6 levels between 1,100 and 2,200 feet which have opened extensive ore bodies. The different levels show much zinc, and the mine is now an important producer of copper-zinc ores, both metals being recovered by the Anaconda process.

The North Butte Mining Co. is mining zinc ore from the 2,000 and 2,200 foot levels, where the zinc ore body is said to be 10 feet in width and to average 19 to 20 per cent zinc. The Anaconda Co. is reported to have contracted for 200 tons daily.

The Davis-Daly Copper Co. began shipments of zinc ore to the Ophir mill late in 1916. The daily output is 50 tons, which will be increased to 150 tons upon completion of the new hoist. It is reported that several drifts show a body of zinc ore 6 to 10 feet wide. The Ophir 200-ton mill was remodeled for flotation equipment in 1916.

Numerous other mines and prospects in the Butte district are known to contain zinc ores. Many of them are in course of development and may become zinc producers. Among these are the Moulton, Raven, Travona, Moonlight, Belmont, Highore, East Grayrock, and Bonanza.

Considerable bodies of zinc ore are reported in the Blue-eyed Nellie mine, 6 miles west of Anaconda. It is said that two carloads of zinc ore were shipped in 1914. The mine formerly produced silver-lead ores. The dump in 1906 contained galena and gray copper, and indicated that the ore was a siliceous replacement of the coarse limestone country rock.

In the Iron Mountain district, the Iron Mountain mine, bought in July, 1915, by the Federal Mining & Smelting Co., produced zinc and lead concentrates in 1915 and 1916. The mine is developed to the 1,850-foot level, which is 250 feet below the tunnel level. There is a good body of zinc ore lying between the 1,500 and the 1,600 foot levels and good zinc ore left in previous operation is reported in other parts of the mine.

Near Troy, Lincoln County, the Snowstorm Mines Consolidated Co., during 1916, erected a hydroelectric power plant and a 300-ton mill and built a narrow-gage railway spur 5½ miles long to connect with the Great Northern Railway near Troy. The principal openings are on the Banner and Bangle vein, which 6 tunnels have opened for a considerable distance horizontally and for a depth of 1,100 feet, developing about 400,000 tons of ore estimated to average 7 per cent lead and 8 per cent zinc, with 3 ounces silver per ton. The ore deposits occupy a fissure cutting sedimentary rocks similar to those inclosing the ore deposits of the Coeur d'Alene district. The gangue consists largely of quartz, calcite, and dolomite. Basic dikes are associated with the ore bodies and at some places occupy the same fissures, but they are believed to be older than the deposits, which are thought to be of magmatic origin.

In the Comet district, the Comet mine was formerly a large silver-lead producer. The ore consists essentially of galena and zinc blende, with which are associated pyrite and chalcopyrite. The property has not been actively operated for several years.

In the Elkhorn district, the Elkhorn mine has been one of the large silver producers of the country. The ore shipped was argentiferous lead-zinc ore. Carload lots shipped in 1894 assayed lead, 13 to 14

per cent; silver, 180 to 223 ounces per ton; zinc, 17 to 33 per cent. During the period of early operation the shipping ore was hand sorted and the dump and tailings piles, comprising 250,000 tons, contain much low-grade lead and zinc ore. An experimental dry chlorination plant was erected several years ago to treat these dumps, and the results promised success, but the large plant erected at Helena was a failure. The property changed hands late in 1916 and is expected to be reopened and actively operated in 1917.

In the Neihart district a large proportion of the ores are silver-lead ores, the lead content of ores shipped ranging from 7 to 15 per cent. Zinc is present in the ores, especially those high in lead, and frequently exceed 10 per cent. Among the mines which Weed reports as having important amounts of zinc in the ore are the Broadwater, Big Seven, Florence, Galt, and Moulton. Of these the first two were operated in 1915, but produced no zinc ore. The Anaconda Co. has recently leased the Galt and some other mines. The Butte & Great Falls Mining Co. is actively prospecting its property which contains silver-zinc-lead ores, and will soon be producing. It is probable that the mixed zinc-lead ore of this district can be profitably worked by the Anaconda electrolytic method.

IDAHO.

PRODUCTION.

Mine production of zinc in Idaho in 1915, in short tons.

County.	From lead ore.	From zinc ore.	From lead-zinc ore.	Total recoverable zinc.
Blaine	.....	71	150	221
Cassia	.....	13	.....	13
Shoshone	26	11,134	23,682	34,843
State total, 1915	26	11,218	23,832	35,077
1914	.....	3,280	17,726	21,006
1913	39	1,148	10,400	11,587
1912	.....	309	6,644	6,953
1911	.....	3,311	859	4,170

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RESOURCES.[1]

Twenty-three mines in Idaho produced zinc in 1915, 1 from lead ore, 11 from zinc ore, and 11 from lead-zinc ore. The lead ore carrying zinc amounted to 212,836 tons, the zinc ore to 111,428 tons, and the lead-zinc ore to 513,325 tons, a total of 837,589 tons of zinc-bearing crude ores. There are two important zinc-bearing areas in Idaho, the Coeur d'Alene region, including Pine Creek, in the northern part of the State, and the Wood River region in the southern part.

The Coeur d'Alene region includes about a dozen mining districts of greater or less importance, and of these five produce considerable quantities of zinc. The total output of recoverable zinc from the first production in 1905 to 1915, inclusive, is 85,344 tons.

In the Summit district, on the headwaters of Prichard Creek, the Terrible Edith was the leading producer in 1915, having shipped several hundred tons of high-grade lead and zinc ores. Lead and zinc concentrates were also produced by the Monarch, Paragon, and Black Horse mines.

In the Beaver district the Interstate-Callahan mine was the largest producer of zinc. This mine is now in point of output the third largest in the United States. The Interstate-Callahan ore body is a steeply dipping, well-defined vein traversing the beds of the inclosing Prichard slate (Algonkian). The deposit is remarkable for the small percentage of minerals other than sphalerite, the mill feed averaging about 28 per cent zinc. Some galena occurs in minute veinlets traversing the sphalerite ore and quartz is abundant locally, but the chief gangue is partly replaced wall rock. In 1916 a three-compartment shaft was sunk to the 700-foot level. About 600,000 tons of ore are reported in sight and about 250,000 tons of tailings have been impounded since the beginning of operations and will be treated in the flotation plant that is to be installed by the beginning of 1917. During 1915 the output of ore was 113,795 tons containing 22,613 tons of recoverable zinc. According to the company reports for the first nine months of 1916, the ore output was 105,908 tons, containing over 21,500 tons of recoverable zinc. The Ray-Jefferson mine, adjoining the Interstate-Callahan on the northwest, has been extensively developed and upon completion of a 250-ton mill now being constructed will be among the important producers of zinc. The extension of the railway now under construction from Mullen up Beaver Creek will benefit both the Interstate-Callahan and the Ray-Jefferson mines and tend to increase their production. It will also make available the site at Enaville purchased some months ago by the Interstate-Callahan for the proposed 1,200-ton concentration plant.

In the Lelande district there are several large lead mines, some of which yield zinc also. The Frisco mine shipped both lead and zinc concentrates in 1915. The 400-ton mill uses wet concentration, flotation, and magnetic separation. The ore body is a vein deposit, 10 to 12 feet wide, now worked to a depth of 2,200 feet, in which zinc blende and galena are associated with fairly abundant pyrite. The gangue consists of quartz and siderite. The ore replaces quartzite

[1] The geologic notes on the Coeur d'Alene and Wood River regions were furnished by J. B. Umpleby and those on the Pine Creek district by E. L. Jones, both of the United States Geological Survey.

and in the present workings contains twice as much zinc as lead. The Green Hill-Cleveland mine produces both lead and lead-zinc concentrates in the 500-ton mill near Wallace. The mill uses wet concentration and flotation.

In the Placer Center or Ninemile district the Success mine was for many years the most important zinc producer in Idaho. The Success ore body lies in the Prichard slate, is of contact-metamorphic origin, and comprises two hook-shaped, roughly tabular bodies, which abut the igneous contact on the sharply curved end and on the other end grade over the metamorphic rock, in which garnet and biotite are fairly abundant. The northern or larger body has been explored from the surface to the 1,300-foot level and stoped most of the distance. The ore carries 10 per cent of zinc and about 2 per cent of lead. In 1915 the output of lead and zinc concentrates was 21,867 tons. The mill was increased to a capcity of 350 tons and other improvements were made, including an aerial tramway. The Rex Consolidated Mining Co. built a 200-ton mill and began operations late in 1916, producing both zinc and lead concentrates. A considerable quantity of old tailings on Ninemile Creek was worked in 1915 and shipments of zinc concentrates were made.

In the Hunter district, in the vicinity of Mullan, the Morning mine made the only zinc output. Beginning with 1911, this mine has annually made an important production of zinc concentrates in the 1,000-ton Morning mill. This mill, equipped for flotation, is situated a mile below Mullan. The Mammoth mill at Wallace, 7 miles from the Morning mine, is being remodeled and equipped with flotation machinery, which will give 500 tons additional milling capacity to handle the output of the Morning mine. The ore consists of galena, associated with pyrite, sphalerite, and a little pyrrhotite. The output of the last four years averages about 7 of lead to 1 of zinc. The gangue minerals are siderite, barite, and quartz. The ore body is on a distinct fissure traversing the Revett quartzite. The ore is deposited in the fissures and crevices of a sheeted zone along the main fissure, and also replaces the quartzite to some extent. The mine has been worked to a depth of 1,800 feet below No. 6 tunnel. Late in 1916 it was announced that a shoot, 20 feet in thickness and running high in zinc, had been opened on an extension of No. 6 tunnel.

The Independent Development Co. has been formed to recover lead and zinc from tailings and sand in Coeur d'Alene River. It is estimated that about 900,000 tons is available and that it carries 4.6 per cent lead and 2.6 per cent zinc, and 3.9 ounces silver to the ton. Flotation machines will be mounted on a dredge.

The Pine Creek district lies a few miles southwest of the Yreka or Wardner-Kellogg district, where there are several large lead mines, headed by the famous Bunker Hill & Sullivan, none of which yield zinc, whereas the mines of the Pine Creek district yield more zinc than lead. Among the properties which give promise of becoming important zinc-lead producers are the Highland-Surprise, Little Pittsburg, Douglas, Constitution, and Nabob mines. The district is now reached by a wagon road 8 miles long extending up Pine Creek from Pine Creek station on the railway. Surveys for a branch railroad have been made, and the line will probably be built soon. The zinc-lead deposits of Pine Creek occur in thinly bedded blue shales

and slates of the Prichard formation in shear zones or fissures adjacent to large faults. The deposits may be designated as metasomatic fissure veins. The development is too meager to determine fully the extent of the ore bodies. The Douglas had developed a vein for 800 feet with an average width of 4 feet; the Little Pittsburg vein for 200 feet on the strike ranges from 4 to 21 feet wide; in the Highland-Surprise and Constitution mines the ore occurs in shoots separated by barren or low-grade vein matter. The greatest depth attained on any of the properties is about 300 feet below the outcrop of the vein. The ore consists of a fine-grained mixture of sphalerite and galena, associated more or less abundantly with pyrrhotite, pyrite, and chalcopyrite. In places pyrrhotite is the most abundant mineral. Some of the ores, notably those from the Douglas and Constitution mines, are very fine grained in texture and are difficult to concentrate. The Highland-Surprise mine is equipped with a 150-ton wet concentration and flotation mill. Both zinc and lead concentrates are produced, the former about five times as abundantly as the latter; the zinc concentrates assay from 37 to 41 per cent zinc. It is reported that 160,000 tons of lead-zinc ore are blocked out. The Little Pittsburg mine is equipped with a 250-ton mill completed in December, 1915, which has made only a small production. At the Constitution mine a 100-ton mill is under construction, but a number of shipments have been made of hand-sorted ore containing from 21 to 34 per cent zinc and from 6 to 14 per cent lead. The Northern Light mine is recently reported to have cut on the 400-foot level a 25-foot vein averaging 7.5 per cent lead and 9.5 per cent zinc. The Douglas mine has had only a small output, but it has a large tonnage of zinc-lead ore blocked out, which is said to average 17 per cent zinc and 6 per cent lead. The property has for some time been bonded to the Anaconda Copper Mining Co., and a first shipment of 400 tons of ore was made in September, 1916. The ore is concentrated at Anaconda and is treated in the electrolytic zinc reduction plant at Great Falls, Mont.

In the Wood River region present interest centers around the old North Star mine in the Mineral Hill district, southeast of Ketchum. This was formerly a producer of lead, but has long been known to contain extensive bodies of mixed sulphides, sphalerite being most abundant. The ore averages about 13 per cent zinc and contains from 6 to 7 per cent lead, and 6.5 ounces silver, and 60 to 75 cents gold per ton. Arsenopyrite is abundant, and stibnite is not uncommon. The dominant gangue is quartz. The ore body comprises a tabular replacement in soft carbonaceous Devonian shales. It dips westward at a moderately low angle and has been opened on several levels. On the old main tunnel level the ore shoot is from 8 to 9 feet wide and has been found continuous for about 800 feet north of a transverse fault, which seems to cut it off on the south. The vertical extent of the shoot is not known, but it has been cut on the Main, Blacksmith, and Plummer levels at points from 600 to 900 feet below the surface. The property, together with the Triumph group adjoining, also a zinc property, was acquired by the Federal Mining & Smelting Co. early in 1916. Active development was immediately begun. A 200-ton capacity mill, utilizing a "dimming" roast and preferential flotation, is nearing completion, and a branch of the Oregon Short Line is being built up the valley of East Fork of Wood

River. The Minnie Moore and the Nay Aug were the most important producers in 1915. Lead and zinc concentrates were shipped from both properties, and lead and zinc ores were shipped from the Nay Aug. The Queen mine near Bellevue also has much zinc in the lead ores. This mine was recently unwatered, and development work is now proceeding in the lower levels.

In the Warm Springs district, southwest of Ketchum, the Boston-Idaho Co. produced and shipped some zinc ore in 1915. The Lucky Boy mine, belonging to this company, was worked intermittently for several years and is said to have produced 2,600 tons of ore containing 45 per cent zinc.

In the Rosetta district several of the old silver-lead mines are known to contain noteworthy quantities of zinc ore. In the Silver Star mine the ore averaged 20 ounces silver, 4 per cent lead, and about 4 per cent zinc. The mine has not been operated since 1888, when it was worked to a depth of 400 feet. The Carrie Leonard mine was worked to a depth of 160 feet, beyond which there was little ore. The ore is said to have averaged 30 per cent lead and 5 to 6 per cent zinc, with 150 ounces of silver to the ton.

In the Black Pine district, in Cassia County, a few shipments of zinc carbonate ore were made from the Deer Lodge group of claims.

UTAH.

PRODUCTION.

Mine production of zinc in Utah in 1915, in short tons.

County.	From zinc ore.	From lead-zinc ore.	From copper ore.	From lead ore.	Total recoverable zinc.
Beaver	709	786	.....	.....	1,495
Boxelder	1,241	.....	.....	.....	1,241
Cache	8	.....	.....	.....	8
Emery	30	.....	.....	.....	30
Juab	1,178	.....	.....	.....	1,178
Salt Lake	112	2,748	.....	.....	2,860
Summit	233	947	.....	.....	1,180
Tooele	599	.....	.....	.....	599
Utah	848	1	.....	.....	.....
Wasatch	.....	2,706	.....	.....	2,706
State total, 1915	4,958	7,188	.....	.....	12,146
1914	1,492	6,495	.....	8	7,995
1913	4,770	4,595	47	17	9,429
1912	2,800	5,729	.....	5	8,534
1911	582	8,338	.....	.....	8,921

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RESOURCES.[1]

Fifty-two mines in Utah in 1915 produced zinc, 34 from zinc ore and 18 from lead-zinc ore. The zinc ore amounted to 34,320 tons and the lead-zinc ore to 385,361 tons, a total of 419,681 tons of zinc-bearing crude ores.

The production of zinc ore in Utah began in 1904. Since that time the State has been a steady producer, with a total output of 70,548 tons of recoverable zinc to the close of 1915. The earlier production was mainly from sulphide ores, but in recent years there has been an important output of oxidized ores. The first zinc reduction plant to be established in the State was an experimental electrolytic zinc plant built in 1915 at Murray. In 1916 an electrolytic zinc plant of commercial size was under construction at Park City.

The San Francisco district produced the first zinc ore in Utah. To the close of 1915 Beaver County had yielded 12,702 tons, most of which came from the San Francisco district. The Horn Silver mine has been the largest producer. The ore deposit occurs mainly as a replacement of a brecciated volcanic rock adjacent to a strong fault that has brought the volcanic rocks into contact with limestone. The principal zinc minerals are the sulphides, sphalerite, and wurtzite, the latter a result of sulphide enrichment. This is one of the few zinc deposits in the world, if not the only one, in which wurtzite is known to be of commercial importance. The greater part of the output of the Horn Silver mine is treated at the custom electrostatic concentrator at Midvale. A flotation concentration plant has been built by the Caldo Mining Co. to treat the large quantity of tailings from the old Horn Silver mill.

The Park City region began the production of zinc in 1905. To the close of 1915 the district had yielded ore containing 22,927 tons of recoverable zinc. Most of the ore bodies occur as replacements of limestone adjacent to fissures. The principal exception is the great Ontario fissure vein in quartzite. Some of the deposits, notably those of the Daly-Judge-Daly West ore zone, consist of mixed lead, zinc, and iron sulphides, together with some tetrahedrite. The lead and zinc minerals are separated during concentration into lead concentrates and zinc concentrates. The principal producers of the district are the Daly-Judge and the Daly West mines. The Snake Creek adit, to drain and develop the Daly-Judge ore body at 3,000 feet depth from the surface, is 14,500 feet in length. Water from the tunnel is utilized in a hydraulic power plant. Both mines have large modern concentrating plants equipped with flotation machinery. Two flotation concentrating plants are recovering zinc and lead concen-

[1] For the greater part of the notes on Utah, particularly those of a geologic nature, the writer is indebted o B. S. Butler, of the United States Geological Survey.

trates from the large accumulations of tailings along Silver Creek, the Broadwater 600-ton mill, 1 mile below, and the Big Four 1,000-ton mill at Atkinson, 7 miles below Park City.

The Bingham or West Mountain district first produced zinc ore in 1909. To the close of 1915 it had yielded 12,342 tons. The lead-zinc ores of the Bingham district occur as replacements of limestone adjacent to fissures and as veins in quartz monzonite. The zinc is obtained by the treatment of the mixed sulphide ores. The largest producers of zinc in 1915 were the Old Jordan, the Telegraph, and the Utah Apex mines. The mill at the Utah Apex mine was recently equipped with flotation machinery. The main shaft was sunk to 1,300 feet and considerable drifting was done at that level. The output of zinc concentrates is capable of considerable increase, as the production of lead shipping ore has been kept down for a number of years on account of its high zinc content. At Midvale two concentration mills, equipped with flotation machines, are operating on different portions of the large accumulation of tailings from the custom electrostatic separator of the United States Smelting Co.

The Tintic district began producing zinc ore in 1911. Since then it has been a steady producer and to the close of 1915 the total yield amounted to 5,955 tons of recoverable zinc. The ores of the Tintic district occur as replacements of limestone adjacent to fissures and as veins in a monzonitic intrusive. The deposits in the limestone are largely oxidized to the depth to which developments have been carried, which is to 1,800 feet in some places. The principal zinc deposits thus far developed lie below the bodies of lead ore which have been mined. The position of the ore suggests that the zinc was leached from the bodies of mixed sulphide ore and redeposited when the solution of zinc sulphate passed downward into the beds of limestone. The ore contains both smithsonite and calamine. Among the principal zinc producers have been the May Day, Yankee, Lower Mammoth, and Gemini mines.

The Ophir district has been a producer of zinc ores for several years. The main production in 1915 was from oxidized zinc ores which occur as a replacement of limestone adjacent to bodies of oxidized lead ore that had been previously mined. The district also contains bodies of mixed lead-zinc sulphide ores.

The Stockton district yields zinc from mixed lead-zinc sulphide ores, which occur as a replacement of limestone. The Bullion Consolidated Mining Co. has been the largest producer.

The Promontory district, near the south end of Promontory Point in Box Elder County, became a producer of zinc in 1915, the deposits having been discovered late in 1914. The Lakeview mines hold the remarkable record of having come to a paying basis in less than 60 days after the beginning of operations. The ore, which consists of zinc carbonate, with some lead carbonate, replaces limestone along north-south fissures, the largest deposits occurring just beneath a bed of shale. The ore-bearing limestone has been prospected for a distance of 4,500 feet and shows numerous openings in ore. The mine is developed by two working tunnels, which intersect the ore horizon, one about 100 feet above the other. From these there are about 10,000 feet of drifts. At the tunnel mouth the ore is screened and hand sorted.

ARIZONA.

PRODUCTION.

Mine production of zinc in Arizona in 1915, in short tons.

County.	From dry or siliceous ore.	From zinc ore.	From lead-zinc ore.	From copper-zinc ore.	Total recoverable zinc.
Cochise	.....	32	12	.....	44
Mohave	.....	4,506	4,185	.....	8,691
Pima	.....	126	.....	.....	126
Pinal	.....	8	.....	.....	8
Santa Cruz	.....	216	.....	.....	216
Yavapai	24	.....	.....	.....	24
State total, 1915	24	4,888	4,198	.....	9,110
1914	.....	2,322	2,574	.....	4,896
1913	.....	2,510	2,175	29	4,714
1912	.....	3,829	550	.....	4,379
1911	4	1,797	480	.....	2,281

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RESOURCES.

In 1915 there were 12 mines in Arizona which produced zinc, 1 from siliceous ore, 8 in zinc ore, and 3 in lead-zinc ore. The siliceous crude ore carrying zinc amounted to 3,000 tons, the zinc ores to 40,458 tons, and the lead-zinc ores to 47,916 tons, a total of 91,374 tons of zinc-bearing crude ores. The greater part of the zinc output of Arizona comes from the Cerbat region of Mohave County, and is produced chiefly by two mines, the Golconda and the Tennessee.

The Cerbat region includes a portion of the west slope of the Cerbat Mountains, and is about 6 miles wide by 12 miles long, embracing the Chloride, Mineral Park, Cerbat, Union Basin, and Stockton Hill subdistricts.

In the Chloride district the Tennessee mine of the Needles Smelting & Refining Co., located 1 mile east of Chloride, has long been one of the greatest lead and zinc producing properties of Arizona. It is developed to a depth of 1,400 feet, and was productive almost from the surface. The upper 400 feet yielded large quantities of rich galena, the main ore chute being 250 by 15 feet in cross section. The 500-foot level contained good ore for a distance of 800 feet. Large bodies of good zinc ore, 12 feet thick, yet remain on the 200 and 500 foot levels. At 1,170 feet in depth the ore body has an average width of 8 feet and a known horizontal extent of 250 feet. There are

now good ore bodies on the 400, 800, 900, 1,000, and 1,400 foot levels. The vein is about 12 feet wide, and the ore lenses in the vein average 6 feet in thickness. The ore occurs in a fissure vein and consists mainly of galena and blende, but carries a fair amount of silver and some gold and copper. The ore is sent to the concentrator at Needles for treatment. The plant has a capacity of 125 tons and is equipped for wet concentration, including flotation, and has also electrostatic separation machinery. The output at the close of 1915 was at the rate of 800 tons of lead concentrates and 1,200 tons of zinc concentrates monthly.

The Midnight mine, located about 2 miles south of Chloride, has produced considerable copper ore. It is opened to a depth of 300 feet and is said to have 25,000 tons of pay ore blocked out in the workings. This ore is reported to include workable bodies of relatively pure zinc ore averaging 30 to 40 per cent zinc. On the 200-foot level, where the lode is 40 feet in width, the average zinc content of the copper ore is 15 per cent.

Other mines in the Chloride district known to contain zinc-bearing ores are the Schuylkill, Badger, Woodchuck, Samoa, Towne, Golden Hammer, and Pinkham mines.

In the Mineral Park district the Keystone shaft is 450 feet deep, and the mine has considerable underground development. The ore consists of pyrite, chalcopyrite, and zinc blende, with silver and some gold, in a quartz gangue. The better grade runs about 200 ounces of silver, 1½ per cent of copper, and 8 to 10 per cent of zinc. A 250-ton concentration plant, with flotation equipment, is under construction, and a three-compartment shaft is being sunk.

In the Cerbat district the Champion, Idaho, Flores, Vanderbilt, and Golden Gem mines are known to contain more or less zinc.

The Golconda mine, in the Union Basin district, 4½ miles east of Mineral station, is the largest zinc producer in Arizona. It is operated by the Union Basin Mining Co., which also owns a considerable number of other properties in the Union Basin, including the Tub and Blackfoot claims. The first zinc ore was produced about 1900, when a carload was shipped from the Blackfoot claim to the zinc oxide works at Canon City, Colo. In June, 1907, another carload was shipped from the Blackfoot to the same smelter. Neither shipment was profitable. In March, 1908, the Golconda mine, which had been worked for gold, silver, and lead for 20 years, came into the control of the Union Basin Mining Co., and the first car of zinc ore was shipped in April, since which time shipments have been continuous. The mine is developed to the 1,200-foot level by a double-compartment incline shaft and a tunnel. The deposits are in veins in the pre-Cambrian complex and seem to be genetically related to intrusives. The Golconda vein can be traced for 4,000 feet. The water level is reached at about 70 feet, above which the oxidized zone yielded rich ores, containing chiefly gold, silver, and lead, with some copper and zinc. The sulphide ores below contain zinc with some gold, silver, and copper and from 1 to 2 per cent of lead. The gangue material is quartz and is at places intimately intermixed with the ore. The zinc blende is dark and contains considerable iron. On the 300-foot level a drift is said to have been driven 200 feet in a 4-foot shoot averaging 50 per cent zinc. On the 700-foot level the stopes now being worked show a 12-foot shoot of good ore. The

output of the mine at present is coming chiefly from the 800-foot level. On the 900-foot level a large tonnage is being stoped from an ore shoot known to have an extent of 850 feet. There is said to be good ore on the 1,000, 1,100 and 1,200 foot levels. On these levels the ore shows for a distance of 1,000 feet. A large quantity of zinc is reported in old stopes in the mine and in the tailings, estimated at 80,000 tons, accumulated from previous operations. The operations of the Golconda 30-ton flotation section of the old mill were so successful that a 200-ton electric-driven flotation mill has been recently built. The Tub vein, which parallels the Golconda vein at a distance of 120 feet west, has produced considerable silver-lead ore. The Tub vein is from 30 to 80 feet wide, increasing in width downward. At the depth of 60 feet there was an ore body of 20 feet in width which consisted of zinc, copper, and lead, with gold and silver. From the upper levels several hundred tons of lead carbonate have been shipped. A crosscut on the 900-foot level of the Golconda extends to and into the Tub vein and both deposits are now worked together.

The Middle Golconda Mines Co. is developing the Big Bethel and Silver properties, which are believed to contain the northern extension of the veins worked at the Golconda mine. The veins are opened by a 100-foot shaft and several drifts. The shaft is being sunk much deeper.

In the Stockton Hill district the Banner Group mine has had a considerable output of gold, silver, and lead ore, the zinc ore having been culled out and thrown on the dump. The mine is developed by adits and several thousand feet of drifts. The ore body is a fissure vein of galena with zinc blende, pyrite, and chalcopyrite in a quartz gangue and carries some gold and silver. The amount of zinc increases toward the northern, deeper part of the mine. The Arizona-Butte Mines Co. has built a very complete concentrating plant to treat ores from this and other mines of the Stockton district. The ore of the De La Fontaine mine and the C. O. D. mine occurs in fissure veins and consists essentially of galena and zinc blende, with silver and some gold. The Shooting Star mine shipped lead and zinc ore in 1915. The vein contains gold, silver, lead, zinc, and copper.

In the Kingman district the Kingman Zinc Co. made shipments of zinc ore in 1916. The Arizona Venture Corporation operates a lead-copper-zinc sulphide deposit, containing gold and silver, and sells crystals of "lenzite" for wireless telegraphy.

The Arizona-Southwestern Copper Co., at Yucca, Mohave County, has a deposit of mixed lead, zinc, and copper sulphides with precious metals.

In Coconino County, the Northern Arizona Lead & Zinc Co. is developing a deposit of silver, lead, and zinc ore in Cataract Canyon, near Mooneys Falls. A small concentrator, to run by water power, is under construction. The ore body lies in a horizontal bed of considerable thickness and horizontal extent.

In the Tiger district of Yavapai County, the Bradshaw Reduction Co. has built a flotation concentration plant, which has been successful in treating the complex ores of the district. The capacity of the plant is being increased from 75 to 150 tons. It has been operating on the old tailings of the Crown King, making gold, silver, copper, and zinc concentrates. When the addition is complete the plant

will treat the output of the Crown King, War Eagle-Gladiator, and Wildflower mines. The property of the Montezuma Mining Co. is near Crown King. The ore consists of lead and zinc sulphides carrying gold and silver.

In Pinal County, on the old Reward property in the Casa Grande district, a zinc sulphide ore body is reported to have been discovered at the depth of 300 feet. High-grade zinc carbonate ore has been shipped from shallow workings. The Mohawk mine in the Mammoth district has shipped high-grade zinc carbonate ore from an open cut.

In the Pioneer (Superior) district of Pinal County, the Magma Copper Co. operating the Silver Queen mine has completed a 50-ton unit of a 100-ton zinc concentrator. The ore of the Copper Queen mine consists in the main of copper sulphides, but from the 1,000-foot level to the bottom of the workings, 1,200 feet, there is a large shoot of zinc ore. The Silver King mine is about 2 miles north of the Silver Queen mine. It has been worked since 1875 to a depth of 950 feet, and has produced a large quantity of high-grade silver ore. The ore body was a stockwork, 130 feet in diameter, in which the ore consisted of galena, sphalerite, and chalcopyrite with silver-bearing minerals. Blake says that concentrates from the "lower levels" averaged about 18 per cent zinc. He visited the mine in 1882 or 1883, when it was 714 feet deep.

In Pima County zinc carbonate and sulphide ores were shipped in 1915 from the Atlas property in the Silver Bell district.

In the Pima (Olive) district of Pima County the San Xavier mine of the Empire Zinc Co. is making large shipments of zinc carbonate ore. The mine has had a large production of ore containing gold, silver, lead, and zinc in the past 40 or 45 years that it has been worked. There are several shafts on the property, one 400 feet deep, one 280 feet, and other shallower shafts. In early operations the zinc carbonate ores were neglected, and there is reported to be much of this ore in sight in the shallower workings as well as large deposits of low-grade sulphide milling ore in the deeper workings. A mill will be erected.

The Mohawk and Spokane-Arizona properties in the Helvetia district are said to be in a promising zinc belt and both have shipped zinc carbonate ores. In the Dragoon Mountain district of Cochise County a promising zinc ore body is reported to have been discovered on the Hubbard property.

On the Hermitage claim 7 miles south of Hereford, it is reported that a large body of lead-zinc ores carrying silver has been blocked out. There is a mill on the property.

In the Warren (Bisbee) district, in the Gardner mine, in the Briggs ground, and between the Southwest and the Czar mines, there are rather large bodies of zinc ore with iron and copper.

In Santa Cruz County, in the Patagonia district, the Duquesne Mining & Reduction Co. owns the Duquesne, Washington, and other properties about 3 miles from the Mexican boundary. The deepest drifts are those connected with the Bonanza shaft, 635 feet in depth, and there are extensive underground workings. The ore deposits consist of mixed copper, lead, and zinc sulphides occurring as contact deposits between limestone and granite porphyry. The Washington

mine has a large body of such ore. The old mill has been remodeled to a capacity of 150 tons including a flotation unit.

The O. K. group, formerly the Glove mine, has made several shipments of hand-sorted lead and zinc ores.

NEVADA.

PRODUCTION.

Mine production of zinc in Nevada in 1915, in short tons.

County.	From zinc ore.	From lead-zinc ore.	From copper-lead-zinc ore.	Total recoverable zinc.
Clark	6,424	4,107	.....	10,531
Elko	316	.....	.....	316
Eureka	7	23	.....	30
Lincoln	1,290	.....	.....	1,290
White Pine	.....	.....	21	21
State total, 1915	8,037	4,130	21	12,188
1914	2,919	3,571	.....	6,490
1913	3,174	4,036	.....	7,210
1912	2,109	4,552	.....	6,661
1911	975	799	.....	1,774

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RESOURCES.

In 1915 there were 36 mines in Nevada which produced zinc, 30 in zinc ore, 5 in lead-zinc ore, and 1 in copper-lead-zinc ore. The zinc ore amounted to 24,816 tons, the lead-zinc ore to 16,940 tons, and the copper-lead-zinc ore to 78 tons, a total of 41,834 tons of zinc-bearing crude ores.

Most of the zinc output of Nevada comes from the Yellow Pine district in Clark County, near the southeast corner of the State. The total zinc production of the district from 1905 to the end of 1915 is 38,191 tons, which is 94 per cent of the output of the State for the same period. From the fifties, when the Potosi mine, then the "Mormon," was first worked for lead, until 1905, lead was the metal produced in largest quantity, but after 1905 it was found that zinc was more plentiful in the mines than lead.

The rocks of the region are limestones, sandstones, and shales which have been considerably folded and faulted, and which at several places are intruded by granite porphyry and quartz monzonite.

The lead and zinc ore bodies, according to Hill, are of the replacement type and occur in limestones in and near fissures. The ores consist of galena with lead carbonate and of zinc carbonate and silicate. A little sphalerite occurs at some mines. The primary ore is believed to have been mixed galena and ferruginous sphalerite in a calcite gangue. When the ground-water level was lowered, and this ore was subjected to oxidation and leaching, the galena was in part changed to lead carbonate, and the sphalerite was taken in solution as zinc sulphate, which reacted with the wall rocks lower down to form zinc carbonate and silicate.

The Yellow Pine mine is the largest zinc producer in the district. The mine is opened to a depth of 950 feet by a shaft inclined at an angle of 35°, from which levels are driven at every 100 feet. Some of the stopes are large, having a width of 100 feet and a length of 300 or 400 feet. New ore bodies have recently been opened on the 600, 800, and 900 foot levels. The mill of the Yellow Pine Co. is at Goodsprings, and is connected by a narrow-gage railroad with the mine and with Jean, a station on the Los Angeles & Salt Lake Railroad. The mill has a capacity of 100 tons per 24 hours, and is in reality a separating rather than a concentrating plant, as all but a few hundred tons of the ore treated goes into the three products made by the mill. The waste is removed on a picking belt, and the ore is fed over a grizzly to a jaw crusher, thence to rolls, impact screens, jigs, and tables. The products are lead concentrate, zinc concentrate, and zinc slimes. The lead concentrate assays 53.2 per cent of lead, 13.75 per cent of zinc, and 28.1 ounces of silver; the zinc concentrate carries 4.4 per cent of lead, 33.2 per cent of zinc, and 2.5 ounces of silver; and the zinc slime contains 7.3 per cent of lead, 35.1 per cent of zinc, and 4 ounces of silver per ton. The crude ore raised in 1912 averaged 16 to 17.5 per cent lead, 27.8 to 29.8 per cent zinc, and 11 to 11.7 ounces of silver to the ton. In 1915 the ore averaged 10.2 per cent of lead, 31.8 per cent of zinc, and 5.4 ounces of silver.

The Potosi mine is the next largest producer of zinc. It is situated on Potosi Mountain, 8 or 10 miles north of the Yellow Pine mine. The mine is developed by adits and numerous drifts, upraises, and winzes, giving several levels both above and below the main adit levels, comprising in all several miles of underground workings. The ore bodies are irregular in size and shape, ranging from dimensions of a few feet to masses 100 feet high and 60 by 150 feet in cross section. There is no concentrating plant, but the ore is hand-sorted into lead and zinc products. The principal ore is a brownish-gray smithsonite with some calamine and considerable galena and lead carbonate. The zinc ores are calcined in an oil-fired rotary furnace before shipping, in order to raise the grade and to save freight. The ore is hauled to the railway on motor trucks. The Potosi mine was recently bought by the Empire Zinc Co., a subsidiary of the New Jersey Zinc Co.

The Green Monster mine is in the northwestern part of the district, at the west end of a western spur of the Spring Mountain Range. It is one of the older mines, and was worked for lead and silver before the discovery of the zinc ores. The mine is developed by two inclines connected with a vertical shaft 350 feet deep and by several hundred feet of underground workings. The zinc ore bodies are reported to be of good size and of good grade. No lead was mined in 1915.

The Mobile mine is high on the mountain, 6 or 7 miles south of west of Goodsprings. An ore body 8 feet in thickness is developed by an adit and winze, and a 2,900-foot tram carries the ore to the wagon road. A good output of zinc carbonate and some lead ore was made in 1915.

The Bill Nye mine, near the Mobile mine, is opened by a short adit, which intersects a fault zone. The ore body is very irregular and has been stoped to a point within 40 feet of the surface. The ore consists of zinc carbonate with considerable lead ore. The zinc ore shipped averages about 40 per cent zinc. The property has been amalgamated with the Akron as the Goodsprings-Bill Nye Mining Co.

The Sultan mine, one of the large producers, is located 8 miles southwest of Goodsprings. The ore body consists of zinc carbonate with lead ore and is opened by tunnels and a "glory hole." The mine is equipped with a 30-ton dry concentration plant.

The Monte Cristo, 6 miles south of Goodsprings, is said to have been the first producer of zinc ore in the district. A large irregular body of zinc ore reaching to the grass roots, and 70 by 40 by 30 feet in size, has been worked out in the last two years, yielding 7,000 tons of 40 per cent ore with no lead. The mine is opened by several large open cuts and a tunnel beneath the large stope. An inclined shaft, reaching below the worked-out ore body, and several winzes show deeper deposits.

The Bullion mine, near the Monte Cristo, was, in 1915, the second largest producer of lead ore in the district. The mine is opened to the 150-foot level, and large bodies of zinc ore are reported to have been recently developed. The mine is equipped with a 50-ton dry concentration plant.

The Bonanza mine is about a mile south of the Monte Cristo mine. Two deposits have been worked, an upper one, essentially a galena deposit with some lead carbonate, and a lower one, of smithsonite. Both deposits are opened by short adits.

The Anchor mine, just south of the Bonanza mine, is located on the top of a high bluff, over 500 feet above the valley, with a 1,200-foot tramway to carry the ore down to the wagon road. A short adit intersects the vein and a 200-foot shaft with three levels has opened up an irregular ore body 40 feet long by 4 to 8 feet wide, increasing to 100 feet wide on the lower level. The mine is equipped with a 40-ton dry concentration plant.

The New Year Annex mine is 12 miles south of Goodsprings and has been worked in a small way for several years; it is now operated by lessees. One lease is making a good output of zinc ore and the other an output of both lead and zinc ore.

The Christmas, Singer, Hoosier, and Frederickson mines are equipped with dry concentrating machinery and make an output of zinc ore.

In addition to the mines mentioned, there are about 20 other mines which had a smaller output, ranging from a few tons up to 200 tons of zinc.

The Pioche district, in Lincoln County, was very active in the early seventies, producing gold and silver bullion. The ore in some mines did not carry enough lead to collect the gold and silver, and it was therefore treated by pan amalgamation with no recovery of the

lead, which went into the tailings. The accumulated tailings resulting from these early operations form stacks at Bullionville and Dry Valley estimated to contain 120,000 tons, and to carry $1.40 in gold, 11 ounces of silver, and 6 to 8 per cent lead. As the tailings are 40 years old, the lead has been completely oxidized to lead carbonate. The tailings are treated with sodium sulphide to render them amenable to flotation in the new 250-ton Prince Consolidated flotation mill at Bullionville near Panaca station.

The Prince Consolidated mines are 3 miles southwest of Pioche, and connected with that place by a railway spur. The mine is opened to a depth of 600 feet and has several miles of underground workings on large bodies of iron manganese ore carrying 3 ounces of silver, 4 per cent of lead, and 5 per cent of zinc. A report in 1912 credited the mine with reserves of 870,000 tons of such ore. The zinc has heretofore been all lost in treating the ore. No work has been done below the 600-foot level (water level), except diamond drilling, which shows silver-lead and zinc sulphides. The ore occurs in fissures and in much-faulted beds replacing the limestone.

The Amalgamated Pioche Mines & Smelter Corporation is the largest producer of zinc in the Pioche district. It operates, among others, the old Raymond and Ely mines, which closed in 1876. At that time it was reported that a winze 300 feet deep in the "Black ledge," starting from the 1,200-foot level (water level) of the Lightner shaft, had entered a large body of silver-lead and zinc sulphides. The ores above water level consisted of silver chloride and lead carbonate. Operations are now mostly between the 1,200 and 1,400-foot levels, where the ores are lead and zinc sulphides, both carrying silver. The ores, which have a siliceous gangue, occur in a fissure 2 to 9 feet in width in quartzite. The ores are heavier where the fissure approaches the rhyolite porphyry Yuba dike, which is mineralized and with which are associated contact deposits. The mine has been recently equipped with a 70-ton mill with flotation machinery, which makes a lead concentrate carrying 60 ounces of silver and 20 per cent lead with considerable iron, and a zinc concentrate averaging 42 per cent zinc. Twenty tons of zinc concentrate are made to 1 ton of lead concentrate.

It is believed that many, if not all, of the old Pioche mines which were rich in silver-lead ores in the upper workings will have lead-zinc sulphide ores below water level.

In Elko County, in the Ruby Mountain range, in the Ruby Valley (South Creek) district the Arthur Zinc Co. operated the Michigan claim in 1915 and made several shipments of zinc sulphide ore. The mine is developed by an incline 80 feet deep, from which a drift is cut in limestone within a few feet of the contact with intrusive granite. The ore consists of lenslike masses of galena and dark sphalerite more or less separated. The property is equipped with a 75-ton mill with jigs and tables.

In the Warm Creek district, also in Elko County, the Polar Star mine, operated by the Clover Mining Co., had a considerable output of oxidized zinc ore in 1915. The mine is opened by a 64-foot shaft with drifts in limestone at 50 feet The limestone is considerably fractured and the ore occurs as a replacement of the slightly brecciated limestone. The ore is also won by shallow open pits over an

area 200 feet wide by 600 feet long. The Nevada Zinc Co. is operating the adjoining Tobar mine. The shipping point is Tobar Station, 15 miles distant.

In 1915 small quantities of zinc were produced in the Ely (Robinson) district of White Pine County and the Mineral Hill district of Eureka County.

CALIFORNIA.

PRODUCTION.

Mine production of zinc in California in 1915, in short tons.

County.	Zinc ore.	Lead ore.	Total.
Inyo	2,309	19	2,328
San Bernardino	20	.....	20
Shasta	4,199	.....	4,199
State total, 1915	6,528	19	6,547
1914	195	.....	195
1913	529	.....	529
1912	2,173	.....	2,173
1911	1,404	.....	1,404

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RESOURCES.

In California 9 mines, 8 in zinc ore and 1 in lead ore, produced zinc in 1915. The zinc ore amounted to 20,246 tons and the lead ore to 10,118 tons, a total of 30,364 tons of zinc-bearing crude ores.

In the copper region of Shasta County zinc ores are associated with the copper ores in the Afterthought, Bully Hill, and Little Backbone districts. The ore, according to Graton, has a higher average content of zinc than of copper, but until recently only in the Donkey mine in the Afterthought district was the zinc ore utilized as a source of zinc. The ore bodies of the region have resulted from the replacement of the country rock (alaskite porphyry) along shear zones. The principal sulphide minerals are pyrite, chalcopyrite, and sphalerite, with some galena and a little gold and silver. The gangue minerals are quartz, calcite, and barite. In the Afterthought mine the ore is so zincky as to be difficult to smelt for copper. Large reserves of ore averaging 20 to 25 per cent zinc have been developed. By manipulation of the special blast furnaces about half the zinc went into the slag and matte, and the remainder was volatilized. In a 128-day run 1,000 tons of zinc was volatilized and lost. An ammonia-carbon-dioxide leaching process was tried out, but the company decided to await results of the electrolytic process worked out at Bully Hill.

In the Baker mine, also in the Afterthought district, zinc ore is associated with argentiferous lead ore.

In the Bully Hill district, the Bully Hill and Rising Star mines are the deepest in the region, having reached depths of 1,100 feet. The copper ores have a high zinc content and contain also some gold and silver. As the copper smelter was closed on account of damage to vegetation by the escaping sulphur gases, the Bully Hill Copper Mining & Smelting Co. turned attention to other methods of reduction. After several years of experiment a system of sulphate-leaching and electrolytic precipitation was worked out, which showed a high recovery of copper and zinc as well as of the precious metals. An experimental plant produced several tons of electrolytic spelter in 1916. A 25-ton plant employing this process is under construction at Kennett by the Mam moth Copper Co. The Arps, Shasta-Belmont, and other properties in this district also contain zinc ore.

In the western part of the Shasta copper region the ore bodies are not so rich but are larger than those in the Afterthought and Bully Hill districts. The copper ore of the Mammoth mine is reported to average 3 per cent copper and 5 per cent zinc, but large bodies of higher-grade zinc ores are found which by means of hand picking may be brought to a shipping grade of about 40 per cent zinc. In 1916 the mine shipped such zinc ore at the rate of about 250 tons daily. Much of the zinc in the copper ore smelted is caught in the bag house, as is also the zinc used in the Sprague process of fume neutralization. All this zinc, heretofore unavailable, will be amenable to treatment in the electrolytic plant, as well as the zinc ore produced by the mine. Zinc ore is also found in the Friday-Loudon mine, near the Mammoth, and in the Balaklava mine 4 miles southwest.

The discovery of a body of lead and zinc sulphide ore in the Eagle Hill mine, in the Genesee Valley district of Plumas County, has been recently reported.

In the foothill copper belt, reaching from Nevada County to Madera County, zinc blende in considerable quantity has been found in several mines. The Valley View mine, near East Auburn, Placer County, was worked for many years as a gold mine, but copper ores were struck in depth. It is reported that recently considerable bodies of zinc blende, samples of which assay 62 per cent, have been developed. At the Campo Seco mine in Calaveras County the copper ore runs 8 to 10 per cent zinc. Zinc ore is also reported in the Borger, Satellite, and Pocahontas mines. In the Radium mine, in Mariposa County, zinc blende with barite replaces schist. The sphalerite is triboluminescent and was supposed to contain radium; hence the name of the mine. The ore is sold for medical uses under the name "Aposozein."

In Inyo County the most important zinc producer is the Cerro Gordo mine, which in the seventies was a heavy producer of silver-lead ores containing some gold and copper. In 1907 a revival of production took place as a result of the discovery of large deposits of zinc carbonate. The mine is developed by a shaft 900 feet deep and by a winze reaching 250 feet lower. There are many miles of underground workings. A tunnel, now in over 7,000 feet, will cut the Union ore body 1,200 feet below the deepest workings. There is a lead smelter at Swansea, near Keeler, but no concentrating plant. The smelter has been idle for several years; it was operated mostly

on the slag pile left from the early smelting at the mines. A recently reconstructed aerial tramway nearly 6 miles long reaches from the mine to the railway at Keeler. The ores are smithsonite, zinc carbonate, galena with some lead carbonate, and a very little sphalerite associated with the unoxidized galena. The ore bodies worked so far are all above the underground water level. The primary ores form replacement deposits in limestone and are believed to be genetically related to an intrusive mass of monzonite porphyry. The zinc carbonate derived from the sulphide ore body by oxidation, leaching, and reprecipitation forms pipes and irregular masses lying principally in the limestone footwall of the old lead stopes. It occurs immediately below the lead ore bodies formerly worked and extends as far as 100 feet laterally from them. A little calamine, zinc silicate, is contained in the zinc carbonate. The carbonate is very pure, considerable quantities containing as much as 50 per cent of zinc, though the theoretical percentage is a little less than 52. On the 400-foot level a pipe 500 feet long and 5 feet in diameter averaged more than 40 per cent zinc. The average of all shipments of the zinc carbonate ore is over 35 per cent zinc. The 7,062 tons of zinc carbonate ore shipped in 1915 is reported to contain 2,277 tons of recoverable zinc. It is estimated that the output for 1916 will be about one-third larger.

In 1916 a new body of zinc carbonate and galena was opened. This was first struck on the 200-foot level, where it had a width of 25 feet, then on the 300-foot level, and now it has been found at a depth of 550 feet, where its width is 10 feet. The ore carries 45 per cent zinc as well as silver and lead.

The Santa Rosa mine in Inyo County, east of Keeler, is being actively developed. A tunnel is being driven to intersect the veins 500 feet below the present workings. The ore contains silver, lead, and zinc, and is hauled 26 miles to Keeler in a motor truck train of 25 tons capacity. The Spear mine, near Keeler, made shipments of zinc ore in 1915.

The Tecopa Consolidated Mining Co., at Tecopa, Inyo County, made a shipment of zinc ore in 1915, and the Wodine mine in the Zabriskie district, shipped zinc ore in 1916. The Rob Roy mine also in the Zabriskie district, has been reopened, and it shipped lead ore in 1915. The mine contains zinc ore also.

Ores carrying zinc have in past years been shipped from the Uncompahgre mine, 20 miles west of Nipton, San Bernardino County, and from the Silverado mine in Orange County.

WASHINGTON.

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RESOURCES.

In Washington in 1915 one mine produced 122 tons of recoverable zinc. In 1911 there was an output of 10 tons of recoverable zinc, but no zinc was produced in the intervening years.

The Metaline district, though usually regarded as a lead district, has, according to Bancroft, as wide a mineralization of zinc as of lead. The Clark or Larsen property of the Lead-Zinc Co. produced 3,111 tons of crude zinc ore in 1915, of which 80 tons of carbonate shipping ore averaged 31.5 per cent zinc. From the remainder of the crude ore 234 tons of concentrates, averaging 41.6 per cent, were made, which contained 122 tons of recoverable zinc. Lead concentrates are also produced equal to about one-tenth the quantity of zinc concentrates, but none were sold in 1915. The property, which covers a large area and contains several veins, is opened by a shaft and tunnels and has more than 3,000 feet of underground workings. The mill, which is operated by hydroelectric power and equipped with crushing machinery and concentrating tables, was increased to 100-ton capacity late in the year and the output for 1916 will no doubt show an increase. It is planned to increase the capacity of the mill to 250 tons and to add a flotation plant in which to treat the tailings now accumulating in the settling pond. The ore deposits on this property consist of mixed galena and zinc blende, with zinc and lead carbonate at places. The ores that have resulted from replacement occur as pockets in dolomite and as disseminations through brecciated and silicified country rock. The principal opening so far is an open pit 50 feet deep; in this the ore body is a vein 15 feet wide between limestone walls and filled with quartz and calcite in which zinc blende is disseminated in small crystals, with masses of galena here and there. Near the surface there is zinc carbonate. Prospecting with the diamond drill is reported to have shown an extensive ore body on the Josephine claim of the Clark property.

The Metaline Oriole property is developed by an adit which follows the vein for a distance of 880 feet. The ore deposit is a vein 18 inches wide and filled with quartz containing galena, zinc blende, pyrite, and chalcopyrite. The hand-sorted ore carried 35 per cent of both zinc and lead, with 30 ounces silver and a little copper. No output was made in 1915.

The Northport district has principally yielded lead, but throughout the district the lead ores are almost always accompanied by zinc sulphide. The Last Chance mine, formerly operated by the Jupiter Lead Co., and the Great Eastern mine were taken over in 1915 by the Norman Mines Co. and shipments of zinc carbonate ore from the latter mine began in January, 1916. The properties lie 6 miles southeast of Northport on Deep Creek. The Last Chance mine is developed by four adit tunnels and several open cuts, comprising in all several hundred feet of development work. The ore is galena containing less than an ounce of silver to the ton, together with some zinc ore in a gangue of calcite and quartz. Several million pounds of shipping ore, produced a few years ago, consisted of a little lead

carbonate, averaging 42 per cent lead, and sulphide ore, averaging 55 per cent lead, with rarely more than 15 per cent of zinc. However, zincky portions of the ore body were naturally avoided in mining the lead ore. The ore occupies a shear zone and is in part a pockety replacement of the adjoining dolomitic limestone. It is reported that in the Great Eastern mine, in March, 1916, the zinc carbonate ore body on the 165-foot level had been proved for a distance of 250 feet and that a crosscut showed the vein to be 30 feet in width and to have 4 feet of ore on both the hanging wall and the footwall, with mixed ore between. Several hundred tons shipped during the early part of 1916 averaged about 30 per cent zinc. Zinc deposits are also reported on the adjoining Empire claim. However, the operations of the Norman Mines Co. were abandoned near the end of 1916, as developments were disappointing.

Copper-zinc ores are being developed in the Rebecca group near Keller, in Ferry County, and in the Skamania mine in the Bald Mountain district, in Skamania County.

The operations of the lead smelter at Northport have greatly stimulated mining in Washington and will undoubtedly result in additions to the known zinc resources of the State.

ALASKA.

No zinc has been recovered from Alaskan ores, but it is known that zinc blende is a common accessory mineral in the gold and silver deposits and in some of the copper deposits.

Several lead and zinc prospects on the mainland east of Wrangell have been described, of which the Glacial Basin group and Groundhog Basin group are well mineralized with lead and zinc sulphides.[1] Some lead ore which contained zinc blende has been shipped from a prospect on Coronation Island. In 1915 a discovery was reported of payable zinc ore at Tracey Arm, a branch of Endicott Arm in the Juneau district.

Other prospects showing zinc blende are near Sulzer, on Cordova Bay, west coast of Prince of Wales Island, and near Cedar Bay, Prince William Sound.

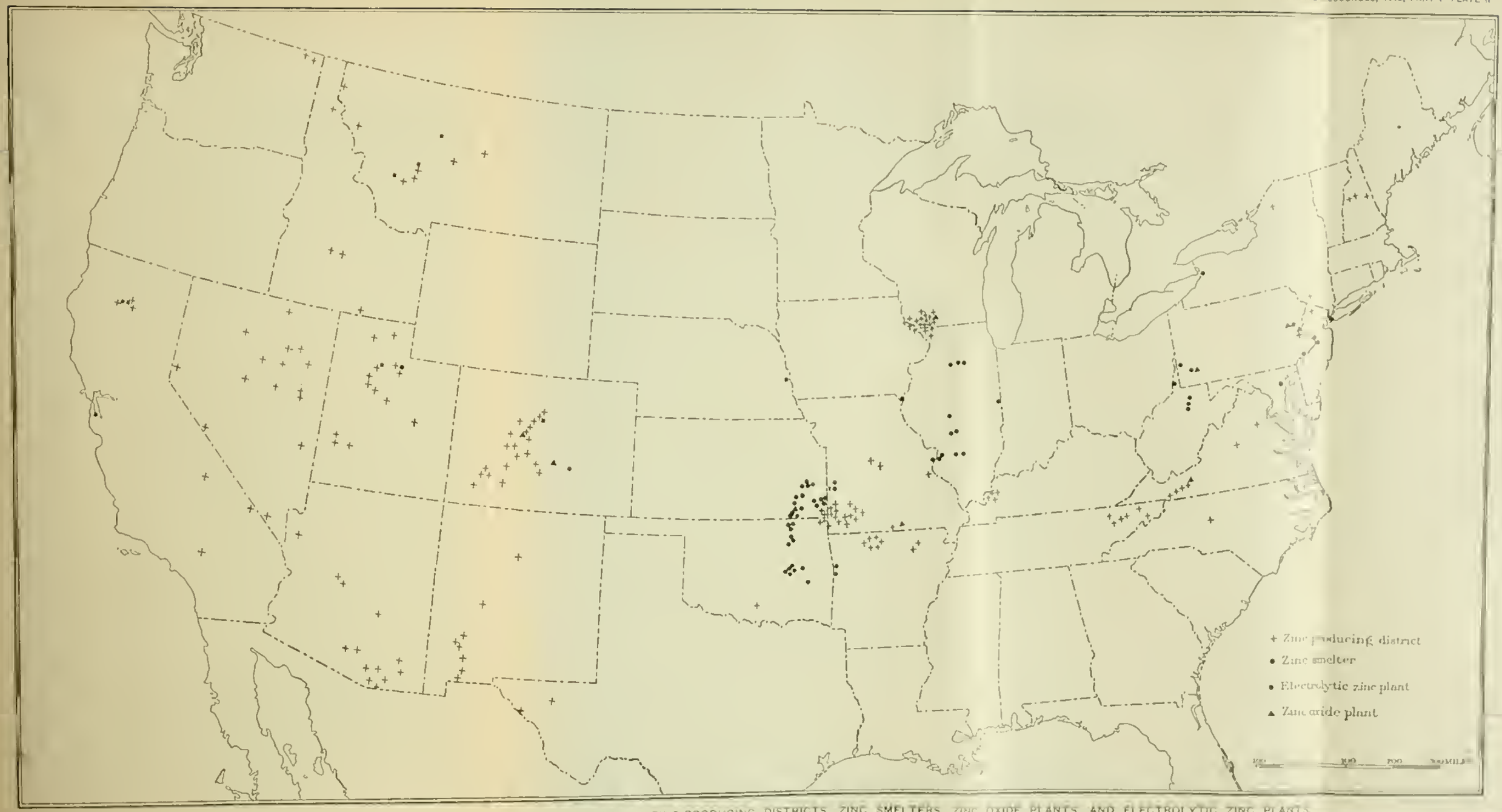
Sphalerite is abundant in some parts of the Ellamar mine,[2] on Prince William Sound, although the copper ores as shipped do not contain enough zinc to be penalized.

Probably the best prospects of a supply of zinc from Alaska lie in the recovery of the small zinc content of large deposits of low-grade gold ores. According to A. C. Spencer,[3] the Juneau region should have a daily output of about 120 tons of low-grade gold concentrates carrying iron sulphide, chiefly pyrrhotite, with 10 per cent of lead and about 3 per cent of zinc. The extent of the ore reserves insures that this output can be maintained for many years. An assay of mill feed shows twice as much zinc as lead, some of the zinc being discarded with pyrrhotite in the tailings. A modification of the system of concentration which would recover the zinc content of the ore as a zinc concentrate would make a respectable zinc output for Alaska.

[1] Wright, F. E., and C. W., The Ketchikan and Wrangell mining districts, Alaska: U. S. Geol. Survey Bull. 347, pp. 186-191, 1908.

[2] Capps, S. R., and Johnson, B. L., The Ellamar district, Alaska: U. S. Geol. Survey Bull. 605, pp. 90-92, 1915.

[3] Oral communication.



MAP OF THE UNITED STATES SHOWING LOCATION OF IMPORTANT ZINC-PRODUCING DISTRICTS, ZINC SMELTERS, ZINC OXIDE PLANTS, AND ELECTROLYTIC ZINC PLANTS.

FOREIGN COUNTRIES.

MEXICO.

Deposits of zinc are found in the States of Tamaulipas, San Luis Potosi, Guerrero, Jalisco, Zacatecas, Nuevo Leon, Coahuila, Durango, Chihuahua, and Sonora, but most of the ore imported into the United States has come from Nuevo Leon, Coahuila, and Chihuahua. No adequate description of the zinc resources of Mexico exists. The following notes are compiled from scattered items in the mining journals and may contain inaccuracies. The zinc ores of Mexico are both carbonates and sulphides. In silver-lead mining before the present century, the zinc carbonate found in connection with the oxidized lead ores was thrown on the dump and the argentiferous lead sulphide ores in which zinc blende was plentiful were avoided in mining. About 1904, however, the demand for zinc in the United States made a market for these ores, and by 1907 the zinc-ore imports into the United States reached large proportions. The tariff act of 1909 reduced the importations to a certain extent. The high prices prevailing in the United States since the early part of 1915 have again led to large imports of zinc ore, as shown in the table on page 963. The imports in 1915 were 57,699 short tons, valued at $2,130,014, and in the first six months of 1916 were 79,663 tons, valued at $3,254,004.

In Chihuahua, in the Parral district, there are silver-lead mines producing zinc near Cerro de la Cruz and Santa Barbara. Near the latter place the San Francisco del Oro mine has reserves of ore with 12.5 per cent of lead and 17.4 per cent of zinc. Blende concentrates from this mine have been shipped to the electrothermic zinc smelter at Trollhättan, Sweden. Other veins yielding zinc in this district are the San Diego and Tecoletes mines. Zinc is increasing with depth in all the veins. Few are worked much below water level. In the vicinity of Chihuahua, the El Potosi mine in the Santa Eulalia district is reported to have large bodies of zinc carbonate at a depth of 1,700 feet. At the rate of 1,000 tons a month, 25,000 tons were shipped to a smelting company in the United States. The El Tajo mine also yields zinc ores. The Calera mine, at San Isidro, west of Chihuahua, is generally considered the largest sulphide deposit in Mexico. The mill employed dielectric separators and pneumatic tables to separate the galena and blende. Near Pichachos the Las Plomosas mines produce lead and zinc carbonate ores. These are rather sharply separated in the ore cavities and the zinc carbonate is very pure, assaying 50 per cent zinc. Calcite and iron oxide are near the walls, then zinc carbonate, with lead carbonate in the center. The mines of the Coyame, Charcos, and Markita districts, west of Presidio, and of the Almoloya district yield carbonate ore. The Los Lamentos and San Ignacio mines east of Villa Ahumada and between that place and the Rio Grande hold large deposits of zinc. At the former mine, worked first as a lead mine, zinc was found on development to be much more plentiful than lead. Zinc blende concentrates assaying 39 per cent zinc were shipped. At the San Ignacio mine the lead and zinc ores are separated on dry concentrating tables. Other zinc mines are at Mojonera and Terrazas.

In Coahuila, in the Muzquiz district, two companies lately resumed production on a large scale. If the ratio of the first three months of 1916 is maintained, the output for the year will be about 20,000 tons of zinc carbonate ore. In the Fierro district the La Penascosa mine produces oxidized zinc ore and lead and zinc sulphide ore. In the Saltillo and Rinconado districts, although lead ores were mined and although only the higher grades of zinc carbonate would pay to ship, great quantities of 30 per cent zinc carbonate ore were thrown into the canyons. Many of these old mines have since been opened and other zinc deposits have been discovered. One of the best known zinc mines in Coahuila is the Del Carmen mine, 8 miles southeast of Boquillas. Ore is hauled 5 miles to a cable tramway 6½ miles long, which stretches across the Rio Grande. From the United States end of the tramway the ore is hauled 80 miles to Marathon on the Southern Pacific Railroad. The ore is calamine, zinc silicate, with very little zinc carbonate and occasionally a very little galena. It is hand picked to 45 per cent zinc. The ore forms chimneys and large replacement deposits.

In Nuevo Leon, in the Monterey district, zinc carbonate ores abound and there are many zinc mines, usually old silver-lead mines reopened. The ore from La Malinche mine assays 35 per cent zinc. The La Paz mine is another zinc mine in this district. The Mines Viejas, at Villadama, 30 miles north of Monterey, was the first heavy shipper of zinc ores to the United States. While the mine was worked as a silver-lead mine, the zinc ore was thrown on the dump. Some zinc ore from this mine has been calcined and shipped to Belgium. The Vallecillo mine, at Sabinas Hidalgo, and the Cruz del Aire mine have also been heavy producers of zinc ore.

In Tamaulipas the Dulces Nombres mine has produced 40 per cent zinc sulphide ores in large quantity, and the Lolita and El Rey mines have shipped zinc ore to Europe.

In San Luis Potosi the La Bufa mine, at Charcas, was abandoned as a silver mine and later taken up as a zinc property. The ore is a contact deposit in limestone adjacent to porphyry and consists of zinc silicate and mixed lead and zinc sulphide ores. The Santa Eulalia mine and the adjoining Morelos mine, also near Charcos, are reported to have large deposits of low-grade mixed lead and zinc sulphide ore. The Tiro General mine yields sulphides from which the zinc blende is separated by dielectric machines.

In Guerrero, at Taxco, zinc blende occurs in large quantities in silver-lead ores, and in Jalisco, at Comanja, zinc blende is the main constituent of the ore.

In Zacatecas there are four zinc-producing mines in the Bonanza district northwest of Mazapil, and there are zinc-silver-lead mines at Sonberete and Plateros. The San Roberto Mining Co. of this State in 1915 contracted to furnish 10,000 tons of zinc ore.

In Sonora the best-known zinc deposits are in the Cananea district. In the Calumet & Sonora mine the upper levels have zinc blende and the lower levels, 500 and 625 feet in depth, carry sulphides of lead, zinc, iron, and a little silver. Electrostatic separators treat zinc middlings from the concentrator, recovering 85 per cent of the zinc and making a 54 per cent zinc concentrate, also smaller quantities of a good grade of copper concentrate. In the Moctezuma-

Arizpe group, the sulphide ore is largely blende in the upper levels and in the lower levels there are equal proportions of galena and blende. The Batamote mine is an old silver mine with a large dump containing silver and zinc sulphide ore.

CANADA.

The zinc resources of Canada, especially in the province of British Columbia, are known to be extensive. The output of zinc ore, however, has been small, and practically all has been treated by the zinc smelters of the United States. The Dominion Government and the governments of the Provinces have been active in trying to develop these zinc resources and to establish zinc smelters. The report of the British Columbia Zinc Commission published in 1906 described the known zinc deposits of that province and considered various methods of concentrating and reducing the ores. A zinc smelter of the ordinary type with 1,200 retorts was built by the Canadian Metal Co. at Frank, Alberta, in 1906, but was not successful in treating the complex sulphide ores. In 1908 the Canada Zinc Co., assisted by the provincial government, built an electrothermic zinc smelter at Nelson, British Columbia, using the Snyder furnace, which also was unsuccessful. From 1910 to 1914, under an appropriation from the Dominion Government, experiments in electrothermic zinc smelting were carried out at McGill University, Montreal, by Dr. Alfred Stansfield, and later the work was continued on a commercial scale at the plant of the Canada Zinc Co. at Nelson. The final report on this experimental work has not been made public. Meanwhile the high price of spelter caused by the war led to experiments in the reduction of zinc ores by roasting, sulphate leaching, and electrolytic deposition. Two electrolytic zinc plants of commercial size and one experimental plant have been built in Canada. The largest is that of the Consolidated Mining & Smelting Co. (Ltd.), at Trail, British Columbia. It has a daily capacity of about 30 tons of electrolytic spelter, and additions now building are expected to bring the output up to 75 tons a day. The ore is roasted, leached with sulphuric acid, and electrolyzed, lead anodes and aluminum cathodes being used and the zinc being stripped from the cathodes, melted, and cast in slabs. The advantages of locating the zinc plant at the lead smelter are apparent when it is considered that the complex lead-zinc sulphide ores of British Columbia form the ore supplies of the lead smelter, which is situated in a region of cheap hydroelectric power that is used already in the electrolytic lead refinery. It is officially announced that the Canadian Government has contracted for the entire output of the new plant.

The Zinc Co. (Ltd.) has built an electrolytic plant at Welland, Ontario. It uses the newly developed Watts process, of which no details are available. It is reported to have a capacity of 10 tons of spelter per day. It is expected eventually to treat zinc ore from Notre Dame des Anges mine in Portneuf, recently leased by the Weedon Mining Co., which is interested in the Zinc Co.

A demonstrating plant using the French process for the recovery of the zinc was operated at Silverton, British Columbia, by the Standard Silver Lead Mining Co. during 1915 with satisfactory results. The

provincial government of British Columbia has granted aid to the promoters of the process by guaranteeing debentures of the company up to $40,000, to be used in adapting to the French process the electric zinc smelter at Nelson, British Columbia. It is expected that the works will soon be producing electrolytic spelter.

The production of zinc ore in British Columbia is mainly from the Slocan district. Among the larger mines are the Standard, Surprise, Hewitt-Lorna Doone, Lucky Jim, Rambler-Cariboo, Ruth-Hope, Slocan-Star, and Galena Farm. In other outlying districts are the Bluebell, Utica, Retallack, Hudson Bay, Zincton, and Monarch mines. The Sullivan mine, of the Consolidated Mining & Smelting Co (Ltd.), is reported to have a proved galena-sphalerite orebody of 3,500,000 tons. There are many other promising mines in process of development. The older of these mines are described by P. H. Argall and others in the report of the zinc commission, as noted above. A recent report of the Ontario Bureau of Mines entitled "Lead and Zinc Deposits in Ontario and in Eastern Canada," by W. L. Uglow, describes working and prospective mines in that area, including the Notre Dame des Anges, Calumet Island, Zenith, and Long Lake zinc mines. The lead and zinc deposits in the vicinity of the Notre Dame des Anges mine, Portneuf County, Quebec, have also been described by Bancroft.[1]

A recent[2] report is that an extensive and rich copper-zinc deposit is being opened at Cape Breton, 30 miles northwest of North Sydney, Nova Scotia. The main vein, 60 feet wide, is said to be traceable for 2 miles. Assays are reported that show 34 per cent zinc, 2½ to 4½ per cent copper, 10 per cent lead, and small amounts of gold and silver.

A list of the zinc concentrating plants in British Columbia in 1916 is given by Wilson.[3]

Zinc ore produced in Canada, 1910–1915.[a]

	Zinc ore shipped.	Zinc content.	Silver content.	Mine mouth value.
	Short tons.	*Per cent.*	*Ounces per ton.*	*Per ton.*
1910	5,063	43.1	21.0	$23.70
1911	2,590	45.3	39.0	39.02
1912	6,415	41.7	27.2	33.54
1913	7,889	44.8	18.2	23.68
1914	10,893	41.8	34.6	21.10
1915	15,553	39.9	.....	40.91

[a] Stansfield, Alfred, Zinc: Canadian Min. Inst. Bull. 52, p. 678, August, 1916. Data for 1915 taken from estimates by John McLeish in Preliminary report on mineral production of Canada for 1915.

This production was mostly from the mines of British Columbia, but in 1915 several hundred tons was derived from the Notre Dame des Anges mine in Quebec. The imports of zinc ore from Canada into the United States in 1915 were 11,992 short tons containing 4,710 tons of zinc and in the first six months of 1916 were 12,865 tons, containing 5,187 tons of zinc.

[1] Bancroft, J. A., The geology of parts of the townships of Montauban and Chavigny and of the Seigniory of Grondines: Quebec Dept. Colonization, Mining, and Fisheries, Mines Branch, Report on Mining Operations in 1915, pp. 103–143, 1916.

[2] Min. and Sci. Press, vol. 113, p. 712, 1916.

[3] Wilson, A. W. G., Report on the production of spelter in Canada: Canada Dept. Mines, Mines Branch, 1916.

GREAT BRITAIN.

The production of zinc ore in Great Britain is not important, yielding less than 6,000 tons of recoverable zinc a year.

In both 1912 and 1913 Great Britain smelted about 65,000 short tons of spelter and imported nearly 160,000 tons a year, so that the normal annual consumption is about 225,000 tons. Figures for 1914 and 1915 are not available, but it is reported that there was a decrease in output of spelter, notwithstanding the high price and the great demand. For the reasons indicated below it was difficult or impossible to increase rapidly the smelting capacity, but progress has been made, and among the new plants are two electrolytic plants. Brunner, Mond & Co., at Norwich (Winnington), have for many years successfully made spelter by the Hoepfner electrolytic process. The process is worked as one in a series of operations in their chemical works, waste calcium chloride being used instead of salt as a source of chlorine, and it produces spelter 99.9 per cent pure, which commands a premium on account of its purity, and yields as by-products chlorine gas and calcium carbonate in a form desired by paper makers. The output of these electrolytic plants naturally must be at a maximum at this time.

For the following list of active zinc smelters in Great Britain in 1916 and the accompanying notes this Survey is indebted to a correspondent.

Active zinc smelters in Great Britain in 1916.

Smelter.	Location.	Capacity.
		Long tons.
Brands Pure Spelter Co. (Ltd.)	Irvine	4,000
British Metals Extraction Co. (Ltd.)	Llansamlet	1,000
Brunner, Mond & Co. (Ltd.)	Winnington (electrolytic)	2,000
Chance & Hunt (Ltd.)	Oldbury (electrolytic)	2,000
Dunstan Metal Co. (Ltd.)	Dunstan-on-Tyne (electrolytic)	1,000
Dillwyn & Co. (Ltd.)	Llansamlet	9,000
English Crown Spelter Co. (Ltd.)	Port Tennant, Swansea	9,000
John Lysaght (Ltd.)	Neatham, Wales	3,000
New Delaville Spelter Co. (Ltd.)	Bloxwich	3,000
Stewarts & Lloyds (Ltd.)	Halesowen	3,000
Sulphide Corporation (Ltd.)	Seaton Carew	5,000
Swansea Vale Spelter Co. (Ltd.)	Llansamlet	9,000
Vivian & Sons (Ltd.)	Morriston, Swansea	10,000
Williams, Foster & Co. (Ltd.)	Upper Bank, Swansea	6,000

The smelting capacity prior to the outbreak of the war was being utilized fully, but afterward, owing to the shortage of supplies of ore, the production fell off, because most of the works were accustomed to treating calamine ore or zinc ashes and drosses, and the large supply of Australian sulphide concentrates could not be smelted, owing to insufficient roasting capacity. This deficiency is now being remedied and there are four new installations of Ridge roasting furnaces, some already running and the balance under construction, the largest having a capacity of 150 tons of ore per 24 hours.

The smelting capacity amounted at the outbreak of the war to 26 per cent of the normal consumption. Additions are being made to a number of smelters and the smelting capacity is being approximately doubled, so that assuming the consumption to remain unaltered, the domestic production would amount to, roughly, half the amount required.

For war purposes, high-grade zinc was principally required, and it is an astonishing fact that the production of this quality has appreciably decreased during the war. Apart from the electrolytic zinc, 5,000 tons of high-grade spelter was made in special furnaces, but, at the request of the Government departments, these furnaces were utilized for making ordinary spelter, which was sent abroad to be refined electrothermically.

The Metal Bulletin, in a recent issue, makes the statement that a new and modern zinc smelter is being constructed near Birmingham by the Ridge Furnace Co., for a firm consuming large quantities of spelter.

The dependence of England on continental Europe for spelter and the dependence of Australia on continental Europe for a market for zinc concentrates has been a source of much embarrassment since the war began and has evoked many proposals looking toward the establishment of large zinc smelting plants in England to treat the zinc concentrates of Australia. No such plant materialized, however, owing probably in part to the financial situation and in part to the fear that the price of spelter after the war may fall to a point unprofitable to the insular smelters. To remedy the latter condition, a bounty and a protective tariff have both been proposed. As shown by the foregoing notes and the notes on Australia further on, relief will probably take the shape of large electrolytic plants in Australia and Tasmania, and a general increase in capacity of British plants to handle the 100,000 long tons of Australian concentrates which Great Britain agrees to take annually for 10 years after the war.

The Zinc Corporation (Ltd.) and the Burma Mines (Ltd.) are jointly interested in an experimental electrolytic zinc plant which has just been erected at Newcastle. The results obtained at this plant will probably determine the treatment of the output of the Burma mines.

The following communication from London in the Mining and Scientific Press of September 8, 1916, is a thoughtful summing up of the conditions, as far as they can be foreseen, that will confront the zinc smelters of Great Britain and other countries as well when the war closes:

The great increase in spelter production in the United States has attracted much attention on this side and, especially now that prices have tumbled, questions are being asked as to what the conditions will be after the war. It is to be remembered that in pre-war days the world's smelting capacity was equal to its demand for spelter. In the normal course of events consumption would have grown and additional furnaces would have been needed by now. When the various nations again settle down to industry it is fair to assume that the tendency toward increased consumption of zinc, which has been a feature of the metal industry for years, will reassert itself. There will, however, be an excess furnace capacity. So far as is known, no considerable portion of the pre-war furnaces has been wrecked. The big chimney of the Overpelt works of Beer, Sondheimer & Co. was blown down by the Belgians and other damage done to the works, and Belgian plants near Liege have suffered some damage. It is impossible also to foretell what may happen if the Germans move out of Belgium. Many of the works are in the probable line of fire, and if the retreat be bitterly contested, further damage is to be anticipated. In a large way though it is true that no considerable amount of plant has been wrecked, and at the end of the war the furnaces that used to supply the world's demand for spelter will still need to be taken into account. Staff and men will be scattered and many will be dead, but the gaps can be filled, supplies purchased, and in general, the old business can be reestablished. If this is not done, the men will work at something else, the plants be converted, and competition will merely be diverted to new channels. The Germans have a large and probably adequate supply of ore within their own boundaries, and, while they were formerly extensive buyers of ore in Australia and elsewhere, but a small part of what they purchased was actually treated in Germany.

If the flow of concentrates from Australia to Europe be diverted, it will be Belgian and French furnaces that will suffer more than those actually in Germany. These facts are beginning to be understood here and, without in the least abating the determination to free the world from German domination of the metal trades, the method is receiving more serious thought than at first. Your own greater expansion of smelting capacity is a matter which gives us pause. Doubtless many of the furnaces now in commission in the United States will not be able to run under normal conditions, but among the new plants are evidently a number which, being well built and well

financed, can stand competition as well as any in the world. With your domestic ore supplies and these new furnaces, it is to be expected that you will play a larger part in the world's spelter market than in the past. There are also the new furnaces in Japan, though to the best of knowledge here the Japanese are not well fortified with ore supplies. Doubtless they can supplement their local resources by drawing upon China, but how far is an open question. Russia is striving to develop home resources, and Austrian prisoners are already making spelter at Ekibastus in Siberia. With all these considerations to face, it has not been an easy problem to determine how Britain is best to take advantage of the great resources in zinc ores found within the Empire, and especially at Broken Hill and in Burma. In round figures the pre-war production of the zinc furnaces in Great Britain amounted to 60,000 [long] tons, and the local consumption of spelter was 200,000. Since the war started, additions to local works have been made or contracted for that will about double the capacity. Zinc smelting has been started in Australia and Canada. The ideal held up here is that the Empire, having the ore, should at least make within its borders the amount of spelter called for by its own industries. To do this entirely would, however, interfere with the industries of Belgium, and there is no disposition to do this. Also, it is questionable economics to multiply too greatly the number of furnaces in a world that will already have an overabundance. The latest proposals therefore look toward cooperation with the Belgian and French smelting companies as well as the British concerns. As a result of negotiations conducted by W. M. Hughes, the Australian prime minister, it is announced that the Imperial Government will finance the movement of Broken Hill concentrates, as Americans have doubtless already learned. The plan is for the authorities to purchase from the mines 100,000 tons of concentrates per year for 10 years. The Government has also agreed to finance the building of Austrian smelters capable of producing 45,000 tons of spelter and to buy the product. The concentrates shipped to Great Britain will be distributed to English smelters for treatment. As a first step the Government has actually purchased from the Zinc Producers' Association 100,000 tons of concentrate, and is allotting this to the British plants for reduction. This was bought on the basis of £25 per ton for spelter, the Government assuming all cost and risk of shipment. These arrangements are to be extended when circumstances permit so as to provide for such French and Belgian plants as may desire to enter the combine. The French plant at Dunkirk is already being allotted ore. All this "socializes" the British zinc industry, to use a word our socialist friends much affect, to an extent that before the war would have been considered out of the question. In effect, the Government assumes the responsibility of providing a market for the miners and, in part at least, for the smelters. It is to act as broker and in this way control the situation without entering the politically dreaded field of tariffs and subventions. Clearly it may make or lose money, or it may do both in turn, but also clearly the the Imperial Government will for some years to come be an important factor in the zinc business and the old *laissez faire* methods are abandoned. So far proposals for buying ore only extend to Australia. What action, if any, will be taken to control the flood of metal that the Burma Mines will soon be ready to supply, remains unknown.

NORWAY.

Zinc has been mined from the Fragg, Hadeland, and Konnerud mines, all of which were equipped with flotation plants when that process of dressing ore was new. There are extensive bodies of low-grade zinc ores in Hakedal and Nannestad, in the neighborhood of Christiania. Several years ago 300 carloads of zinc ore was shipped from the dumps of the Odal mine, which has been idle for a long time. The Ranen lead and zinc mines are at Mo in the Nordeland district. The concentrator, operated by hydroelectric power, is at Drammen. A recent consular report says that a zinc reduction plant has been built at Drammen by the Norwegian Zinc Electro-Metal Co., which will employ an electrolytic process. The plant will have a treatment capacity of 10,000 tons of ore a year, and special attention will be paid to ores containing from 8 to 30 per cent of zinc which have hitherto been considered worthless. At Sarpsborg the electrothermic zinc smelting plant had a capacity in 1913 of 10,000 tons. These works and those at Trollhättan, in Sweden, also using

the de Laval furnace, are owned by the Hydraulic Power & Smelting Co. (Ltd.), in which the Sulphide Corporation and the Zinc Corporation are reported to hold an interest. It is reported that there is also an electric zinc smelter at Ihlen. The output of the smelter at Sarpborg consists mainly of refined spelter produced from spelter of common grade shipped in from other countries.

SWEDEN.

The chief zinc mines of Sweden are the Ammeberg mines, in the province of Nerike, and the Rylls Wytlang. At the former the ore consists of zinc blende associated with galena and pyrite and occurs in lenses of considerable size in Laurentian gneiss. After concentration and roast-magnetic separation, the ore assays 42 per cent of zinc. The Sala silver and lead mines were first worked in the early part of the sixteenth century. The immense piles of tailings made in the centuries of operation contain workable quantities of zinc as do also the mines, for the more zinciferous areas were avoided in mining the silver and lead ores. The electrothermic zinc smelter at Trollhättan has a capacity of over 6,000 tons of spelter. New works of increased capacity were built in 1913. The crude zinc product of the furnaces is refined in another electric furnace and brought up to 99.9 per cent purity. In 1914 the output was 10,028 short tons of which 2,523 tons were refined spelter. In 1915 the output increased to 17,349 tons, of which 9,469 tons were refined.

SPAIN.

The following notes on the zinc resources of Spain are given by Ahlburg:[1]

Calamine is the chief zinc ore, though blende has been found in large quantity in the southeastern metalliferous belt, including Cartagena, Mazarron, and the Sierra Almagrega. The neighborhood of Cartagena at one time furnished a large output of calamine, and the workings round Almeria still yield a certain quantity. In the Province of Teruel, at Linares, a deposit of calamine attaining a maximum thickness of 42½ feet is worked in Mesozoic limestones, by but far the most important center of the Spanish production of zinc ore is the Province of Santander. The largest deposits here occur in the great Carboniferous limestone range of the Cordillera Cantabrica. Over an area of 6¼ miles in length and 1½ miles in breadth calamine is found in "nests" in the limestone, which is extensively dolomitized in the vicinity of the ore. The latter is very pure, and with it are associated, but in small proportion, lead and copper ores and some rare streaks of cinnabar. In depth, undecomposed zinc blende has been occasionally found. The later group of calamine deposits, extending eastward into the Provinces of Biscay and Guipuzcoa, occur in Mesozoic, more especially Cretaceous limestones. The output has diminished rapidly of late years, but this northwestern region of Spain still accounts for the greater part of the output of zinc of the country.

The output of the zinc mines of Spain is more than equal to the capacity of the two Spanish zinc smelters, at Aviles, on the north coast, and at Penarroya, and the surplus has heretofore been disposed of in other countries. The war closed some of these markets and Spanish zinc ores have been reaching the United States in large quantities since the beginning of 1916. According to the records of the Bureau of Foreign and Domestic Commerce, Department of

[1] Ahlburg, J., Die nutzbaren Mineralien Spaniens und Portugals; Zeitschr. prakt. Geologie, vol. 15, pp. 183-210, 1907. Abstracted in [British] Inst. Min. Eng. Trans., vol. 36, pp. 734-738, 1909.

Commerce, the imports of zinc ore from Spain in the first six months of 1916 were 38,239 short tons, containing 16,006 tons of zinc and valued at $1,051,315.

In 1914 the production of zinc ore in Spain was 126,012 short tons and the output of metallic zinc was 15,152 short tons, consisting of ordinary spelter, 9,678 tons; refined spelter, 2,219 tons; and sheet zinc, 3,255 tons.

ITALY.

The Sardinian lead deposits were known and worked by the Romans and it is said that the lead for the water pipes of ancient Rome and Pompeii was derived from these mines. Prior to 1865 the calamine encountered in mining for lead was discarded in the dumps. Since that time the zinc ores have been mined and for the last 10 years have been more important in value than the lead ores. The production of calamine ore was 92,000 tons in 1870 and this gradually increased to 127,000 tons in 1900, since which time the annual output has ranged between 100,000 and 130,000 tons.

The Sardinian calamine mines are situated for the most part in the Iglesias mining district,[1] which occupies a mountainous area in the southeastern part of the island. The deposits of lead and zinc are chiefly in the hands of two companies, the Società di Monteponi, working by open pit the enormous body of oxidized zinc known as the Cungiaus mine and the lead vein deposits near by, and the Società di Pertusola, controlling some four groups of mines, some of the groups covering from 4 to 5 square miles of territory and consisting of oxidized ores of zinc in limestone or of vein deposits of galena and sphalerite in granite and schist. Each company has a lead smelter, the one at Monteponi in connection with the mining and concentrating plants, and the other at Pertusola, near Spezia, in Italy. Neither company has had a zinc smelter, and the zinc ores have usually been marketed in Germany or Belgium. The war having closed that market, arrangements were made to dispose of the ores in the United States, with the result that Sardinian zinc ores began to enter this market about the middle of 1915, and a total of 5,312 short tons of ore were imported in 1915, and 7,525 tons during the first six months of 1916.

Zinc ores are also found in northern Italy in Lombardy, Piedmont, and Tuscany. The English Crown Spelter Co. operates its works at Swansea, Wales, upon ores from its mines in the Province of Bergamo in northern Italy.

The London Mining Journal of September 9, 1916, says that the Società di Monteponi is reported to be erecting a zinc smelter to treat ores hitherto exported to France and Belgium.

The production of zinc ore in 1914 was 160,841 short tons, compared with 168,958 tons in 1913.

AFRICA.

The Rhodesia Broken Hill ore body consists of a large deposit of oxidized zinc-lead ore in northwestern Rhodesia, according to a report in the Mining Magazine. Great quantities of ore are in sight

[1] Wright, C. W., The lead and zinc mines of Monteponi: Min. Mag., vol. 12, pp. 33–38, 1905; Calamine mines of Sardinia: Eng. and Min. Jour., vol. 100, pp. 625–628, 1915.

at the surface. One outcrop is estimated to show 250,000 long tons of ore averaging 26 per cent of lead and 22½ per cent of zinc, and another outcrop is estimated at 300,000 long tons, averaging 32 per cent zinc, with little lead but much iron oxide and carbonate. Great difficulty has been experienced in finding a commercial process to treat the ores, and there has consequently been no output from the mines. According to recent reports development is being pushed rapidly and lead and zinc smelters are being erected.

Tunis and Algeria also produce zinc ores, both sulphide and carbonate, the output from Algeria amounting annually to 85,000 tons and that from Tunis to 30,000 tons. These deposits have long been exploited by the large zinc-smelting companies of Belgium and by Vivian & Sons (Ltd.), the English zinc smelters. Among the most important zinc mines of Algeria are the Ouarsenis mine, southwest of Orleansville, and the Amarko mine, 20 miles from Oued-Zenati, both deposits being of oxidized ores. Another large mine is the Djebel Ouasta, 30 miles southeast of Souk-Ahras. The ore occurs at the contact of Cretaceous limestone and Triassic shales. The N'Bail-Kef-Semma deposits were worked as early as 1872, and had an output in 1913 of over 11,000 tons of ore. Practically all the ore raised is carbonate and silicate, few of the mines being deep enough to reach sulphide ore. The ores are calcined and thereby raised to a zinc content of 50 to 60 per cent. It has been reported recently that a zinc-smelting works has been established in Algeria.

In 1915 there was imported into the United States from French Africa, 2,464 short tons of zinc ore, containing 1,152 tons of zinc.

RUSSIA.

There are deposits of zinc in Russian Poland, which were formerly very productive but now are nearing exhaustion; they are probably an extension of the Silesian zinc deposits. The chief mines are the Ulisses, Joseph, and the Boleslav, all located near Olkusch. The ores at the Boleslav mine, producing one-half of the total output, are carbonates and silicates, which, at discovery, formed a mass 2,000 feet in diameter and 50 feet in thickness. There are three smelters, the Paulina works, the Constantine works, and the Pod Bendinom works.

Another zinc-producing area of Russia is in the northern Caucasus. Here the Sadon deposits, belonging to the Société d'Alagir, have been worked a long time for silver-lead ores. In 1904 the zinc ores began to be worked and a zinc smelter was built at Vladikavkaz, in northern Caucasus. The plant is reported to be efficient and has an output of about 4,000 tons of spelter, as noted in the table below. The zinc ore supply from the Sadon mines, however, has not latterly been sufficient for the smelter and further supplies have been obtained from the Elboruss mines. These mines have been recently discovered and have proved very rich. They supply not only the Alagir smelter in part, as noted above, but also the Elboruss Co.'s smelter, built in 1915, to smelt zinc and lead ores. The Elboruss Co. is bound by the terms of the crown loan to deliver all metals produced to the Russian treasury.

Zinc deposits are also found in Finland, and there is reported to be an electrothermic zinc-reduction plant at Helsingfors.

Deposits of zinc have long been known in Siberia, and some of them have been developed to the point of production. In 1907 there were shipped 1,116 short tons of zinc ore and 9,072 tons in 1908 from the mines in the Ussurisk district. In 1909 it was reported that the Tyuticha mine, near Olga Bay, 200 miles northeast of Vladivostok, had shipped 36,000 tons of zinc ore to Germany. The ore body consists of a large deposit of calamine, known to contain at least 200,000 tons,[1] averaging 48 per cent zinc. There are in this vicinity several other mines of which not much more is known than the location. In 1913 there was imported into the United States from Siberia 1,792 short tons of zinc ore, containing 1,397 tons of zinc, which possibly came from the mine just mentioned. No ores have since been received from Siberia. It is noted below that arrangements have been made by the Mitsui Mining Co., and other companies for shipping zinc ores to Japan from mines in Siberia convenient to that country.

The Ridder mine, of the Irtysh Corporation (Ltd.), in the Semipalatinsk district of southwestern Siberia, has been recently described.[2] The mine is about 50 miles east of Irtysh River, and about 750 miles upstream from Omsk, on the Trans-Siberian Railway. It is represented as one of the world's most important mineral developments of recent years. It was formerly worked for its oxidized ores, but the present objective is a large body of sulphide ores beneath the old workings. The exploration work by H. H. Knox yields an estimate of 883,000 long tons of solid sulphide ore, averaging 31 per cent zinc, and 2,448,000 long tons of disseminated ore, averaging 5.6 per cent zinc. Zinc and lead smelting plants are being constructed adjacent to the Ekibastus coal fields on the river about midway between the mines and Omsk. The first unit of the zinc smelter is now in operation with a capacity of 5,000 long tons a year. It is of the ordinary retort, distillation type, treating zinc concentrates, which assay 42 per cent zinc, and producing spelter 98.5 per cent pure, which at present is redistilled, raising it to 99.5 per cent. Another unit is in course of erection and will be completed by the end of 1916. Other units will be added as the output of the mines increases and as skilled workmen become available. A railroad connecting the mines with Irtysh River has been built.

Zinc ores and spelter produced in Russia, 1913–14, in short tons.[a]

Province.	Zinc ores.		Spelter.	
	1914	1913	1914	1913
Poland	[b] 36,000	72,906	[b] 4,500	9,046
Caucasus	10,598	13,740	2,654	3,750
Eastern Siberia	22,370	29,484	.....	.....
	[b] 59,000	116,130	[b] 7,000	12,796

[a] General view of the principal branches of the metallurgical and mineral industry of Russia: Department of Mines, Petrograd, 1915.
[b] Estimate.

[1] Purington, C. W., The Tyuticha zinc mine: Min. and Sci. Press, vol. 99, p. 200, 1909.
[2] Eng. and Min. Jour., vol. 99, pp. 599–603, 1915; from H. H. Knox's report to the company.

INDIA.[1]

The Bawdwin silver-lead mines of eastern Burma are at Lashio, near the Chinese border, in the Northern Shan States, and 169 miles from Mandalay. They are on one of the large ore bodies of the world. They are authentically known to have been worked by the Chinese as far back as 1412 A. D. The Chinese worked the oxidized parts of the ore body principally for the silver, losing the greater part of the lead in the slag, great heaps of which remain to mark the sites of early smelting operations. The Burma Mines (Ltd.) was formed in 1904 to take over these mines and exploit them, but active mining operations did not begin until 1909. In 1911 the lead smelter was removed from Mandalay to Nam Tu, 13 miles from the mines. Lead is being recovered from the old slag dumps at the rate of 1,000 tons a month, while development work is proceeding in the mines. In August, 1915, the proved and probable reserves of sulphide ores were estimated at 2,000,000 long tons, having an average assay of 25 ounces silver, 27 per cent lead, and 22.5 per cent zinc. In August, 1916, the estimated reserves had increased to 3,500,000 long tons. A 6,000-foot tunnel will be completed in the latter part of 1916, when the mines will be able to supply 1,000 tons of ore per day, or over 60,000 long tons of recoverable zinc per year. Pending the provision of smelting facilities for the zinc, the mixed lead-zinc ores were being sold to European smelters before the war. The war having closed that market, mining operations in 1915 and 1916 were restricted to the monthly production of 4,500 long tons of high-grade lead-silver ore, for which there are available markets. The Swansea Vale zinc smelting works at Llansamlet, Wales, have been recently taken over by interests associated with the Burma Mines (Ltd.), and it has been reported that they would be largely increased in capacity to handle the zinc ore output of the Bawdwin mines. An experimental electrolytic zinc plant has been established by the Burma Mines (Ltd.), and the Zinc Corporation (Ltd.) at Newcastle, England. Therefore it is uncertain whether these zinc ores will be reduced in England, Australia, or in the vicinity of the mines.

FRENCH INDO-CHINA.

A very useful account of the zinc mines of the Tonkin protectorate has been given by Lawrence P. Briggs,[2] United States Consul at Saigon, from which the following notes are taken:

The zinc deposits of Tonkin occupy a territory about 50 miles wide and 100 miles long, in which there are four productive districts, comprising about 30 zinc concessions, of which only 11 are at present working. Present development has all been since the French occupation and dates from 1906. The first mine discovered in the Tuyen-Quang district now has an annual output of 10,000 metric tons. The mines of the Thai-Nguyen district produce annually about 15,000 tons, and those of the Than-Moi about 6,000 tons. The Chodien district is the youngest and most promising. The

[1] Since the notes on India were compiled a good description of these mines entitled "The geology of the Bawdwin mines, Burma, Asia," by M. H. Loveman, has appeared in the Bulletin of the American Institute of Mining Engineers for December, 1916.

[2] Briggs, L. P., The zinc mines of Tonkin: U. S. Dept. Com. Repts., No. 230, pp. 1224–1228, 1916.

mines of this district were not opened until 1914, after the construction of a railroad 22 miles long from the mines to Song-Gam River. In 1914 the output was 1,900 metric tons and in 1915 it was 8,600 tons, with 15,000 as the probable production in 1916. The ore is mined from an open pit in the side of a hill and 80,000 tons of 52 per cent calamine ore is said to be in sight.

The ores are mostly the oxidized forms and are found at shallow depths, so that the simplest mining methods are in vogue and the labor is performed by Tonkinese coolies at 15 to 20 cents a day. The mines are equipped with modern ore-dressing machinery generally operated by electric power. The ores are crushed, washed, calcined, and sacked for shipment. They are carried on small boats to the river and transshipped by larger boats to Haifong. Under the present conditions it is profitable to mine only the richest ores, near the surface, at the most accessible mines. The erection of a smelter at some central location is being considered.

The exports of zinc ore from Tonkin in 1913 were 27,732 metric tons; in 1914, 19,562 tons; in 1915, 33,335 tons; and for 1916 they are expected to be 50,000 tons, as all mines are running at utmost capacity. Prior to 1915 the total customs value of the ore delivered at tidewater at Haifong averaged about $650,000 annually, but for 1915 and 1916 the value will be over $1,000,000. Before 1915 the ore was exported chiefly to Belgium, but in 1915 it went to France, Japan, and the United States. The exports to the United States in 1915 were 7,814 short tons. Allowing for transportation delays it is apparent that, in the table of zinc ore imports on page 964, the imports from China and Hongkong in 1915 as well as part of the imports credited to China in 1916 must have originated in Indo-China in 1915.

CHINA.

The zinc deposits of China are chiefly in the southwestern part, in Kweichow, Hunan, Szechwan, and Yunnan provinces. The Shui-K'ou-Shan lead and zinc mines in Hunan Province, near Sungpo, on Siang River, 30 miles south of Hengchow, have been worked for centuries and to-day have a large production. The mines, which are under the control of the Hunan Official Mining Board, have, in the last few years, been equipped with modern German ore-dressing machinery, and there is a 3-mile narrow-gage railway from the mines to Siang River. Four modern shafts are worked, one about 800 feet deep. Some of the shallow mining is yet done in the primitive Chinese way. The mines employ about 5,000 men. It has been decided to build a smelting plant with a daily capacity of 100 tons of lead and zinc. As mined, the ore assays 23 to 29 per cent zinc, 19 to 33 per cent lead, and 18 to 21 ounces silver. In 1914, according to one report, the mines produced 25,820 short tons of zinc ore and 8,540 tons of lead ore. Wheeler,[1] who gives the following account of the mines, states the production in 1914 somewhat differently:

An examination of the geological structure shows that the ore carrier is limestone covered to the north and west by slightly unconformable red sandstone and shale. An intrusion of syenite has tilted these into the form of an anticline, the crest of which has since been denuded. The ore deposit consists of large irregularly shaped bodies

[1] Wheeler, A. S., Metalliferous mines of Hunan Province: Far Eastern Review, September, 1915, pp. 134–138.

of mixed galena, zinc blende, and iron and copper pyrites, which have been formed at or near the contact of the syenite and the limestone, as a result of this intrusion. Official reports, covering the past 20 years, show that the mine has produced during this period over 50,000 tons of lead concentrate and over 126,000 tons of zinc concentrate, but there were extensive native workings prior to 1896, probably dating back for centuries. A portion of the mine is still worked in native fashion, but the main workings consist of an incline shaft sunk to a depth of over 600 feet, off which four levels have been driven, and of a small vertical shaft 160 feet deep below this point, serving the fifth and sixth levels. The ore is rough sorted underground and then cobbed and close sorted at surface. This yields clean high-grade lead and zinc ore, ready for shipment. The balance is a mixed product of varying size. The lumps are partly stacked as a reserve at surface and the remainder, together with the coarse, goes to the foreign plant for treatment. The dust and small pieces are sent to the Chinese dressing floors.

In the foreign plant the ore is first crushed and sized and then fed to mechanical jigs and Wilfley tables which produce a lead concentrate and a zinc concentrate and intermediate products; the latter are at present being stored for future treatment. The Chinese process consists of repeated hand jigging in baskets, which yields lead and zinc concentrates and a mixture. The latter is treated by washing down an inclined plane several times, whereby lead concentrate is separated out, the balance going to waste. The capacity of the foreign plant is about 50 tons per day and of the Chinese plant rather less. A new foreign plant with a capacity of 100 tons per day is in course of erection. During 1914, a total of nearly 56,000 tons of ore was treated, yielding 5,000 tons of lead concentrate and 14,600 tons of zinc concentrate. These respective products are stated to average 70 per cent of lead with about 8 per cent zinc, and 30 to 40 ounces silver per ton, and over 30 per cent of zinc with 5 to 10 per cent lead impurity. The cost of producing a ton of concentrate is about $13, local currency, excluding depreciation, amortization, etc. The concentrates are sold under contract to Messsrs. Carlowitz & Co., of Hankow, who re-treat them in their works at Wuchang, whence they are shipped to Europe to be smelted. An experimental lead and zinc smelting plant using native methods has been established by the Hunan Board near Sungpo, where both these metals and also silver are being produced.

Considerable zinc is smelted in China in small clay retorts in primitive plants. The output is not known but is estimated at 1,000 to 2,500 tons a year. The grade of purity is about 98 per cent both for the modern output and for that made in the Ming dynasty in the sixteenth century.

Robertson [1] has described these primitive zinc smelters and Chinese methods of mining:

> The zinc furnaces hold from 48 to 72 fire-clay pots, 6 inches in diameter at the top and tapering to 1 or 2 inches at the bottom and 18 inches deep. The ore receives no preliminary calcining, but is mixed with coal and filled into the pot. A cylindrical extension 6 or 8 inches long is luted on the top. A small stick is placed against the side of this to provide a passage for the zinc vapor, and a layer of fine molding sand is packed in and scooped out to form a little cup to receive the condensed zinc. A flat fire-clay cover is placed on top and luted all round, except for a little hole on one side for the gases to escape through, and the pot is then ready for the furnace. They put through one charge per 24 hours. The pots cost about 1 d. each and last about 30 charges. The yield from these ores is 1 to 1.5 catties [1.3 to 2 pounds] of zinc per pot. It requires 4 men to operate each furnace of 72 retorts. At present all the zinc is being sent to Yunnan-fu for export, because the manufacture of cash has been suspended on account of the high price of zinc.[2]

Another form of combined retort and condenser is described as an elongated clay pot, which is let about half of its length into the top of the furnace. The pot is filled less than half full of the charge, and an inclined clay partition is luted into the pot, closing off the charge except for a small hole at the highest point of the partition. The top of the pot is then closed with a clay plate. When the charge is

[1] Robertson, J. A. T., An engineer's travels in western China: Min. Mag., vol. 15, pp. 267–279, 1916.
[2] Idem, p. 276.

heated, the zinc vapor rises into the chamber above, which, being outside the furnace, condenses the vapor, which collects in the lower part.

A recent issue of the Engineering and Mining Journal quotes the Imperial Maritime Customs figures for the exports of zinc from China in 1914–15, as follows:

Zinc exported from China, 1914–15, in tons.

Form.	1914	1915
Zinc ore	8,126	9,415
Spelter	342	2,566
All other forms of zinc	2,175	9,872

JAPAN.

Japan has within a few years become a producer of zinc ores and more recently has begun to produce spelter in important quantities.

Zinc ore was first produced in 1905 and by 1913 the output had risen to about 38,223 short tons, valued at $426,875. A production of over 70,000 tons is predicted for 1916. The largest producer, the Kamioka mine of the Mitsui Mining Co., is situated about 45 miles south of Toyama. This mine, said to have been opened 1,200 years ago, is on a concession of over 7,000 acres and has been opened to a depth of 1,000 feet. The ore consists chiefly of argentiferous galena and zinc blende and occurs as irregular contact-metamorphic deposits, in size ranging up to 50 by 300 feet. Other large mines are operated by Takata & Co. and the Kuhara Mining Co.

The following data representing the zinc-smelting industry of Japan, for which the Survey is chiefly indebted to T. Hirabayashi, of the Japanese Bureau of Mines, and J. Kojimi, of the Ashio Copper Co., are repeated here, with some modifications, from the chapter on zinc in Mineral Resources for 1914.

The Osaka-Ayen Co., a subsidiary of the Fujita Co., operates a zinc smelter, which in 1915 had a capacity of 6,000 tons of spelter a year. It uses retorts of the usual type and is located at Konoshima, on a small island in the inland sea between Honshu and Shikoku. It is being enlarged to two or three times its present capacity. The company owns two small mines, but depends almost altogether on custom ores.

The Mitsui Mining Co. has a zinc smelter of modern German design utilizing waste heat from coke ovens at the Miike colliery, in the Fukuoka district. It has a capacity of 10,000 tons a year and an addition of 50 per cent is planned. The Mitsui Mining Co. has large zinc mines and smelts its own ores for the most part, but has lately made arrangements with owners of Siberian zinc mines for additional ore to supply the enlarged plant.

The Niphon Ayen Co. four years ago established an electrolytic zinc plant in the Niigata district. It is operated by hydroelectric power and has a capacity of about 600 tons a year.

The Fujita Co., operating the Kosaka zinc mine in the Akita district, has likewise for several years been making spelter by an electrolytic process. The capacity of the plant, which is also run by hydroelectric power, is about 250 tons a year.

The following notes, extracted from an illustrated booklet describing the operations of the Fujitagumi (Fujita Co.), published in September, 1916, give late information relative to the expansion of the Japanese zinc smelting industry:

OSAKA AYEN KOGYO KABUSHIKI KAISHA (OSAKA ZINC MINING & SMELTING CO. (LTD.)).

The enterprise of spelter production in Japan was first started in 1911 by the Osaka Zinc Mining & Smelting Co., a subsidiary of the Fujitagumi. The zinc company has four smelting plants, two of them being retort distillation smelters of Rhenish-Belgian type, and the other two plants employing an electrolytic process of the company's original design. The annual consumption of zinc ores for the four plants is nearly 60,000 metric tons and the production is about 18,000 tons. The foreign ores used are imported chiefly from Siberia, China, Tonkin, and Australia. About one-third of the spelter produced by the Fujita Co. is used in Japan, and the remainder is exported to Great Britain, France, and Russia, mostly for munition purposes. Some zinc dust is exported to the United States of America.

A recent consular report says a zinc smelter has been built by the Susuki Shoten at Hikoshima. The ore will come chiefly from Australia and Siberia, and will be first treated in the company's ore dressing plant at Chofu. The smelter will have a capacity of 10,000 short tons of refined spelter.

The electrolytic smelters were largely experimental and have been operated irregularly. The spelter produced is very pure, but is very expensive and can not ordinarily be sold in competition with other commercial spelter. The whole product has heretofore been sold to the Japanese Navy Department. Up to a year ago none of the zinc smelters in Japan paid a profit on their operations. The demand for high-grade spelter for munitions has no doubt caused the electrolytic plants to be run to full capacity. During 1915 and 1916 Japan engaged extensively in the munitions industry, the output going largely to Russia. Zinc smelting capacity has been greatly increased and new smelters have been reported, but details are lacking. The spelter output for 1914 was 6,554 short tons and for 1915 was 23,421 tons. The output in 1916 is expected to be much larger. About 6,000 tons of refined spelter was exported in 1915. Before the war the output of zinc concentrates was largely exported and some reached the United States as late as 1915, but the increase in spelter output has absorbed the domestic ore supplies, notwithstanding they have been increased 50 per cent, and has necessitated the purchase of ore from Siberia and French Indo-China, and in addition Australian concentrates have been contracted for.

AUSTRALIA (NEW SOUTH WALES).

The principal source of zinc in Australia is the silver-lead mines of Broken Hill, New South Wales. In the early days of Broken Hill mining the crude ore ran about 25 per cent each in lead and zinc and 25 ounces in silver, but by 1904 the average tenor had become reduced to 16 per cent each of lead and zinc, with 11 ounces of silver to the ton. At present the average tenor is probably somewhat below those figures. In the effort to get rid of the zinc it was heaped up in enormous piles of zinc tailings and slimes from the concentrating plants, and lead concentrates with 20 per cent of zinc were smelted, lead slags averaging 16 per cent of zinc oxide with a maximum of 20 per cent having been run, according to Donald Clark.[1] Various leach-

[1] Clark, Donald, Australian mining and metallurgy, p. 372, Melbourne, 1904.

ing, electrolytic, and magnetic processes were successively tried and finally discarded for the flotation processes which have been in practical use since 1903. This method of concentration has the advantage that it can be applied to the current output of zinc tailings and slimes as well as to the accumulated stocks of those products. The success of electrolytic methods of reducing zinc ore in the United States has led to the formation of companies to establish electrolytic zinc works in Australasia, as is noted elsewhere.

The importance of flotation in that country is shown in the following table of the production of zinc concentrates at Broken Hill by flotation methods for the period 1913–1915, compiled from the annual reports of the department of mines of New South Wales. These concentrates are recovered from zinc middlings and tailings, both from the current product and from the stored accumulations of bygone years of milling operations. The minor quantities of lead concentrates recovered, as a table product from the zinc concentrates, are not included.

Zinc concentrates produced at Broken Hill, New South Wales, 1913–1915, in long tons.

Company.	Flotation process used.	1913		1914		1915	
		Tailings treated.	Concentrates.	Tailings treated.	Concentrates.	Tailings treated.	Concentrates.
Sulphide Corporation	Minerals separation.	174,287	63,446	152,146	52,059	.....	73,063
Broken Hill Proprietary	Potter-Delprat.	349,290	85,685	246,682	53,596	280,867	69,985
Amalgamated Zinc (De Bavay's).	De Bavay.	498,289	140,098	412,823	115,204	317,239	91,663
Zinc Corporation	Minerals separation.	350,120	86,230	221,620	48,325	.....	.....
Do	Horwood	.....	.....	.....	3,986	.....	.....
British Broken Hill	Minerals separation.	26,754	6,356	.....	(a)	.....	.....
Junction North	.....	68,426	16,944	.....	(a)	.....	.....
Total concentrates produced.	.....	.....	398,759	.....	273,170	.....	234,711
Average zinc content, per cent.	.....	.....	47.0	.....	47.1	.....	47.6

a Treated by Zinc Corporation.

The subjoined table compiled from the annual reports of the department of mines of New South Wales shows the quantity and zinc content of zinc concentrates exported from New South Wales from 1904 to 1915:

Zinc (spelter and concentrates) exported from New South Wales, 1904–1915, in short tons.

Year.	Concentrates.	Zinc content.	Year.	Concentrates.	Zinc content.
1904	64,514	24,996	1910	524,862	207,085
1905	115,956	34,313	1911	578,343	213,321
1906	114,984	37,438	1912	582,980	217,520
1907	264,601	85,842	1913	567,482	206,247
1908	309,044	127,515	1914	402,427	163,968
1909	418,775	161,300	1915	213,826	101,059

Further details as to present stocks of tailings and current and future output, will be found in the chapter on zinc in Mineral Resources for 1913, Part I, pages 636–638.

The zinc smelter of the Broken Hill Proprietary Co. (Ltd.), at Port Pirie, at last accounts had 10 distillation furnaces with 1,440 retorts. It is planned to add more furnaces gradually until the output is brought up to about 25,000 tons a year. A spelter refining plant and a zinc rolling mill are also contemplated. The output of the plant in 1914 was 5,616 short tons. Production during 1915 was considerably increased, the output January 1 to June 2 being 3,194 short tons, or at the rate of 7,500 tons per year. Figures for the latter part of the year are not available.

On June 2, 1915, the Broken Hill Associated Smelters Co., composed of the Broken Hill Proprietary Co., North Broken Hill (Ltd.), Broken Hill South Silver Mining Co., and the Zinc Corporation, took over the zinc smelter and the lead smelter also at Port Pirie, and belonging to the Broken Hill Proprietary Co. (Ltd.). The participating companies agree to dispose of their whole output of lead concentrates for the next 50 years to the new corporation. The Sulphide Corporation (Ltd.), having a lead smelter at Cockle Creek, New South Wales, is not participating in the Broken Hill Associated Smelters Co.

The Zinc Producers' Association Proprietary (Ltd.) is a cooperative selling agency, the members of which are zinc-producing companies of Australia and Tasmania that are pledged for 50 years to sell through the association the whole of their output of marketable ore, concentrates, spelter, or electrolytic zinc. Seventy per cent of the Australian output of zinc concentrates is controlled by the agency, and the zinc output of the Burma Corporation will also be handled. It is believed possible that ultimately the Zinc Producers' Association may control the sale of 85 to 95 per cent of the zinc ores of the British Empire.

An arrangement has been concluded between the British and the Australian governments by which the British Government agrees to advance £500,000 toward the erection of a spelter plant in Australia, to purchase annually for 10 years after the close of the war 45,000 long tons of Australian spelter, and in addition to purchase annually 100,000 long tons of Australian zinc concentrates.

At least two electrolytic zinc plants are to be established in Tasmania, one at Northwest Bay by the Complex Ores Co. (Ltd.), with a capital of £250,000, and another by the Electrolytic Zinc Co. of Australasia, with a capital of £1,000,000. The latter company is affiliated with Amalgamated Zinc (De Bavay's) (Ltd.), and the works will be located at Risdon, near Hobart.

The Mount Lyell Mining & Railway Co. has taken over the Mount Read and Roseberry mines, in the Zeehan district, on the west coast of Tasmania, and will probably employ an electrolytic process to treat the complex ores, as it is negotiating for 25,000 hydroelectric horsepower. These mines have reserves of over 800,000 tons of ore assaying 29 per cent zinc, 7.5 per cent lead, 9½ ounces silver, and 2 pennyweights gold.

Among the allotments and options of hydroelectric power to be developed in Australia and Tasmania are said to be 10,000 horsepower allotted and 40,000 horsepower optioned to the Amalgamated Zinc (Ltd.), and 20,000 horsepower allotted and 30,000 horsepower

optioned to another important Australian company not mentioned by name. The first electrolytic zinc plant to be built will have, it is reported, an initial capacity of 10,000 or 11,000 long tons of spelter a year, and an ultimate capacity of 40,000 tons, using the equivalent of 100,000 tons of Australian concentrates.

After much delay the foreign contracts which controlled the output of Australian zinc concentrates were abrogated and in 1915 Australian concentrates were shipped for the first time to the United States. The imports of Australian concentrates into the United States in 1915 were 76,410 short tons containing 29,723 tons of zinc and valued at $1,843,801. During the first six months of 1916 the imports rose to 82,775 tons containing 38,133 tons of zinc and valued at $2,225,790.

METALLURGY.

CONCENTRATION.

PROGRESS OF FLOTATION CONCENTRATION.

The successful use of flotation concentration has made a great zinc-producing district of the Butte (Mont.) region, is making an important zinc district out of the Coeur d'Alene (Idaho) region, and is increasing the production of zinc and lead in many other States.

A brief description of several ore-flotation processes was given in Part I of Mineral Resources for 1908 (pp. 251–256). Since that time, however, various improvements have been made in the different processes and new processes have been invented. These were reviewed in Part I of Mineral Resources for 1913 (pp. 639–642). Nothing further calls for mention at this point except to chronicle the great expansion in the use of ore flotation in the treatment of copper sulphide, lead sulphide, zinc sulphide, and mixed sulphide ores in the United States.

Much experimentation upon the different phases of flotation has been undertaken at private laboratories, at the metallurgical laboratories of the manufacturers of flotation machinery, at plants already in operation, at schools of mines and engineering, and at the laboratories of the United States Bureau of Mines. At Salt Lake City the United States Bureau of Mines is cooperating with the School of Mines of the University of Utah in the study of metallurgical problems. There has recently grown up an extensive literature of ore flotation, most of which will be found included or summarized in the following volumes treating of ore flotation which have recently appeared:

Hoover, T. J., Concentrating ores by flotation, 3d ed., Mining Magazine, London, 1916. $3.50.

Rickard, T. A., The flotation process, Mining and Scientific Press, San Francisco, 1916. $2.

Megraw, H. A., The flotation process, McGraw-Hill Book Co., New York City, 1916. $2.50.

Stander, H. J., The flotation process, Mining and Engineering World, Chicago, 1916, $3.

Cunningham, Jesse, List of references on concentrating ores by flotation: Missouri Univ. School of Mines Bull., vol. 8, No. 1, Rolla, 1916.

Ore flotation was tried unsuccessfully at many places in the West several years ago, but not until its successful application to the zinc ores at Butte, Mont., did it begin to receive practical consideration.

It made progress rapidly, however, and is now being used in treating zinc ores in Tennessee and Montana, lead ores in Missouri, and mixed lead and zinc ores in Colorado, Utah, Idaho, and elsewhere.

In southeastern Missouri practically the whole of the lead production of 210,440 tons in 1915 was made in concentration plants having flotation equipment. From the imperfect data at hand it is estimated that about 20,000 tons of this output is an addition due to flotation alone, and it is calculated that the average mill recovery is now nearly 85 per cent compared with 77 per cent before flotation was adopted. In flotation, as in other forms of concentration, the richer the feed the higher the percentage of recovery. In southeastern Missouri the higher mill recovery under flotation has permitted lower-grade ore to be treated, and thus the increase in average mill recovery as given above does not furnish a true indication of the advantage derived from using this process.

At Butte, Mont., the Butte & Superior Copper Co. has been operating a concentrating plant at the Black Rock mine since 1910, and flotation equipment was added in 1912. The mill recovery of zinc before the adoption of the flotation process was 55 per cent, but since flotation was installed the mill recovery has greatly increased, being 86.4 per cent in 1913, 91.3 per cent in 1914, and over 92.2 per cent in 1915. The recovery during the first half of 1916 was 92.9 per cent. The recoverable zinc content of the concentrates produced in 1915 at this plant was about 70,000 tons. At 55 per cent recovery without flotation, the yield of recoverable zinc would have been about 42,000 tons. This indicates a clear gain of 28,000 tons of recoverable zinc a year at a single plant. A part of this gain, however, is doubtless due to improved efficiency in other sections of the mill. As practically all the 93,573 tons of zinc produced in Montana in 1915 was concentrated in mills with flotation equipment, the gain due to flotation in Montana may be estimated at about 35,000 tons of zinc.

Ore flotation is extensively employed in treating the lead and lead-zinc ores of the Coeur d'Alene district of Idaho. J. M. Callow has stated that one flotation process is used at the Gold Hunter, Morning, Hercules, Bunker Hill & Sullivan, Caledonia, Last Chance, Hecla, and Standard mines, which employ 50 flotation cells and treat daily from 1,500 to 2,000 tons of fines and slimes. Other processes are in operation at the Interstate-Callahan, Greenhill-Cleveland, and other mills in the district. Figures as to tonnage treated and mill recovery are not available, but as almost all the zinc and 97 per cent of the lead output of Idaho came from this district, the gain due to flotation may be estimated on the basis of the gains elsewhere on similar ores, at 22,000 tons of lead and 12,000 tons of zinc.

Ore flotation is employed in the treatment of lead and zinc ores at many places in Colorado and at some places in other Western States. A fair estimate of the additional recovery of lead and zinc in 1915 due to the flotation process is 50,000 tons of each metal. The gain due to flotation is really more than this, however, for the higher recovery allows the profitable working of lower-grade ores, and the metal recovered from such ores should be credited to flotation.

The Joplin region and the upper Mississippi Valley region are two districts where ore flotation is not extensively used. The Missouri

Bureau of Geology and Mines, the Missouri School of Mines, and the United States Bureau of Mines are cooperating in experimental work with ore flotation in the Joplin region, and the State University of Kansas and some operators are working independently to the same end. According to C. A. Wright,[1] the mill recovery of zinc in the Joplin district is at present 60 to 70 per cent, 30 to 40 per cent being lost in the slimes and tailings. He is of the opinion, after a series of tests, that the Joplin ores are amenable to flotation, as shown by the following:

> It was found from the preliminary results, that the sulphides of this district are apparently not difficult to separate from the gangue by flotation, and that a fairly good grade of concentrate could be obtained by the use of "rougher" and "cleaner" cells. Oils with a tar base gave a high recovery but a low-grade concentrate carrying a considerable amount of gangue. Other oils gave higher-grade concentrate, but not as good an extraction under the same conditions. The best results were obtained from wood creosote and pine oils.
>
> The addition of acid may not be absolutely essential for all the ores of the Joplin district, although the local tests showed that a small quantity of acid was of great help, especially in cleaning the concentrates.

The division of State chemical research of the University of Kansas made a series of flotation tests upon Joplin slimes and succeeded, in the most successful tests, in floating 73 per cent of the zinc.[2] In later experiments on Joplin tailings made at the University,[3] recoveries of 98 per cent were obtained, but the concentrates were not workably rich. With other oils and under other conditions very rich concentrates were obtained, but the recovery was not high enough. Among the most successful tests was that with 4 pounds of hemlock oil and 4 pounds of concentrated sulphuric acid to the ton which gave an extraction of 83 per cent; and 1 pound of hemlock oil gave a concentrate assaying 46.3 per cent zinc. Another test with 4 pounds of pine oil and 8 pounds of acid to the ton gave an extraction of 77.4 per cent; and 2 pounds of pine oil gave a concentrate assaying 53.2 per cent zinc.

It is apparent, when the best combination of temperature, acid, and oil or oils is found, that a fairly high extraction can be obtained from the slimes and tailings in the Joplin district. This recovery for the slimes and tailings added to the ordinary recovery should give a total of at least 75 to 80 per cent.

A great many of the concentrating plants in the Joplin region are too ephemeral for anything like a general adoption of flotation, but it should be possible to employ this process to such an extent as to raise the average mill recovery to 75 or 80 per cent. This would increase the recoverable zinc output 15 per cent, or 23,000 tons a year, and would make possible the mining of much lean sheet ground, thus adding to the ore reserves of the region.

At several flotation plants treating mixed sulphide ores a system of preferential flotation has been adopted. The ore is given a "deadening" or "dimming" roast by which copper, lead, and iron sulphides are slightly oxidized on the surface, but the zinc sulphide is not affected. When the ore is subjected to flotation the zinc

[1] Wright, C. A., Possibilities of flotation for lead and zinc ores in the Joplin district: U. S. Bur. Mines. [Issued in mimeograph form.]

[2] Belchic, George, and Allen, G. L., Flotation of Joplin-Galena slime: Met. and Chem. Eng., vol. 13, p. 847, 1915.

[3] Whitaker, W. A., Belchic, George, Neal, Roy, and Van Velzer, R. L., Flotation experiments on a Joplin tailing: Met. and Chem. Eng., vol. 15, pp. 131–137, 1916.

sulphide is readily separated from the "deadened" sulphides, which do not float.

The field of ore flotation promises to be widened materially by the treatment of oxidized ores so as to coat them with a film of sulphide, thus rendering them amenable to flotation. There are large quantities of zinc carbonate ore at Leadville, Colo., which are too low in zinc tenor to be available for use at the local zinc oxide plant, though this plant treats ore containing as low as 14 per cent of zinc. This low-grade carbonate ore is not susceptible to ordinary wet concentration, but it might be beneficiated by such a sulphide-film flotation.

On the whole, it seems not unreasonable to expect that the more general employment of ore flotation may be capable in a year or two of adding from 50,000 to 100,000 tons of zinc to the yearly output of the country. This does not mean necessarily that the production will be that much larger, for the output of course depends on the demand. If it is not larger, however, the districts with less advantageous facilities for production will have been eliminated to that extent.

ELECTROMAGNETIC AND ELECTROSTATIC SEPARATION.

Roasting and magnetic separation continues to be the general method of eliminating the iron from the marcasite-blende ores of the upper Mississippi Valley district. There were 9 roasting plants in operation and 1 under construction in the district in 1915. Some of these did custom work in addition to handling the output of the mines where located, and some did wholly custom work. By giving a very light roast, the pyrite is separated in a condition suitable for sale to sulphuric acid manufacturers. An electrostatic separator was built in this district in 1908 which was operated until destroyed by fire in 1911. Though successful in operation it was not rebuilt, possibly because it is more expensive than the roast-magnetic plants which also do good work. Moreover the atmospheric conditions in the district are not the best for such a process. In the drier climate of Colorado, New Mexico, Utah, and California electrostatic separation is in most successful operation.

In New York, in the Edwards district, the Northern Ore Co. has to contend with a galena-blende-pyrite ore in a gangue containing considerable barite. Success was finally attained by handling the blende-pyrite-barite middlings on Weatherby wet magnetic tables. These are inclined tables with deep riffles operated in a very strong magnetic field. The tables make a clean blende product and a pyrite tailing with some zinc which is sold to sulphuric acid and paint manufacturers.

Another method of handling a somewhat similar ore was developed by the Calumet & Sonora Mining Co., at Cananea, Mexico.[1] The treatment on the electrostatic machines separated the lead, copper, and iron sulphides, while the zinc sulphide on account of its poor conductivity remained with the gangue of calcite, barite, and silica. By immersing the tailing for a few moments in a very dilute bath of copper sulphate, a thin film of copper sulphide was formed on the zinc sulphide, but not on the gangue minerals, and re-treatment on the electrostatic machine gave a clean zinc blende product.

[1] Min. and Eng. World, vol. 35, p. 389, 1911.

REDUCTION.

GENERAL STATEMENT.

The high price of zinc prevailing since early in 1915 has greatly stimulated experimentation in wet methods of reduction of zinc ore, either in purely chemical ways or, more especially, by combinations of chemical and electrolytic methods. The installation of the electrolytic process in plants in the United States having an aggregate daily capacity of 200 tons of spelter and in Canadian plants of 100 tons daily capacity, either now in operation or under construction, would seem to be conclusive evidence that electrolytic reduction of zinc ore has arrived. The higher percentage of electrolytic recovery and the purity of the product offset, under present conditions, the greater cost of production and with perfection of methods may continue to do so even under normal conditions. Nothing further advanced than experimental plants has materialized either in the line of purely chemical reduction or in electrothermic reduction. The rapid development of the electrolytic process seems to have eclipsed all other new forms of zinc reduction.

ELECTROCHEMICAL REDUCTION.

A list of the plants in the United States employing electrolysis in the reduction of zinc ores is given on page 949, and electrolytic zinc plants in Canada, England, and Japan are mentioned in the discussion of the zinc resources of those countries. The proposed plants in Tasmania are mentioned under Australia. Electrolytic zinc is being made in France at the Perrier-Lloyd plant, at Marseille. The methods of procedure vary more or less at the different installations and the details are guarded with secrecy, except as regards the process in use by the Anaconda Copper Co. at Anaconda and Great Falls, Mont. As these installations comprise fully half the present capacity of this country for the production of electrolytic spelter, a description of the Anaconda process will answer, perhaps, for all purposes. The following account of the Anaconda method is by Frederick Laist,[1] who is co-patentee with F. F. Frick:

> I can hardly claim that we have accomplished anything especially new in this line, except in so far as we have done on a somewhat larger scale what had often been done before by others in the laboratory and in a smaller way. Briefly, the process consists of concentrating the zinc ore, preferably by flotation, so as to make a concentrate with as little insoluble matter as possible and as rich in zinc as the nature of the ore allows. This concentrate is roasted in two of the furnaces of our copper-leaching plant, so as to produce a calcine containing from 2 to 3 per cent sulphur, most of which is present as sulphate sulphur. The temperature is not allowed to exceed 1,350° F. (732° C.), under which conditions the formation of zinc ferrite is not pronounced.
>
> The calcine, after cooling, is treated with a solution containing sulphuric acid, which dissolves the zinc and a little of the iron. A small amount of manganese dioxide is added for the purpose of oxidizing the iron, which is then precipitated by means of a small amount of powdered limestone. Any arsenic or antimony is carried down by the precipitated ferric hydroxide. The resulting solution contains nothing but zinc, cadmium, and copper, and is separated from the residue by filtration. The residue contains the lead, silver, and gold and part of the copper originally present. The solution is treated with metallic zinc to precipitate the copper and cadmium and is then pumped through a clarifying filter press into a storage tank, from which it goes to the

[1] Ingalls, W. R., Electrolytic zinc: Am. Electrochem. Soc. Trans., advance copy, read at New York Feb. 11, 1916.

electrolytic cells. The cell room contains 42 tanks, which are in no way different from those commonly used for copper refining. Here the zinc is deposited on aluminum plates.

The solution from the cells contains sulphuric acid and is used for leaching a fresh charge. The zinc deposits on the aluminum plates are stripped off every 48 hours and sent to the melting furnace. At the present time we are making about 5 tons of zinc per day of a high degree of purity.

The Mammoth Copper Co., a subsidiary of the United States Smelting, Refining & Mining Co., is erecting an electrolytic zinc plant of 25 tons daily capacity of spelter at Kennett, Cal. The plant will treat 65,000 tons of bag-house dust, which has been accumulating since the start of the smelter in 1910, and which contains both zinc and copper resulting from the neutralization of furnace fumes by the Sprague process. The mines of the Mammoth Copper Co., in common with the other copper mines of Shasta County, contain much zinc sulphide and it is reported in the mining press that 700 to 800 tons of hand-sorted zinc ore has been shipped monthly to the smelters in Kansas since the middle of 1915. The electrolytic plant will treat the ore as well as the bag-house dust.

Electrolytic deposition of zinc may find a field in connection with the igneous concentration of complex sulphide ores. The River Smelting & Refining Co. has an electrolytic zinc plant at Keokuk, Iowa, which treats the zinc oxide and basic lead sulphate product of a fire-concentration plant at Florence, Colo., producing electrolytic spelter. The lead sulphate residues are sold to lead smelters.

The Fields process offers a possibility of being applicable to deposits of mixed carbonate and sulphide ores of zinc. The following note is abridged from an account in the Engineering and Mining Journal of November 27, 1915:

A 25-ton experimental flotation plant employing the Fields process is being installed at the Ohio Copper Co.'s mill at Lark, Utah.

The recovery at the Ohio Copper mill has been only 64 or 65 per cent, and if the Fields process is successful it will be used to treat the accumulated tailings, which include a 3,000,000-ton slime pile which carries about 0.8 per cent copper. The 25-ton experimental plant is being installed in the western part of the mill, where it can cut in on any part of the feed. Experiments will be started first on the slime pile.

In a general way the process combines flotation and leaching and appears to be adapted to the handling of partly oxidized copper ores. Concentrates and electrolytic copper are produced. The crushed ore or tailings are placed in a cell with water to which a little sulphuric has been added, and agitated by air under 50 to 75 pounds pressure. Electric current, at from 10 to 25 volts, with the amperage depending on the size of the cell, is passed through the solution between copper electrodes. The current breaks down the water into hydrogen and oxygen, and these gases assist in the flotation of the sulphide particles, which are skimmed off. The oxidized portion of the ore is dissolved and deposited as electrolytic copper. The cost of treatment by this process, as indicated by experiments carried on at Maxville, Mont., on 1.57 per cent copper ore, was approximately $1.25 per ton of material treated.

According to Dorsey A. Lyon, lead smelters treating zincky ores may find it profitable to submit their ores to leaching and electrolysis to remove the zinc before smelting in the blast furnace. It is said that even if such smelters should lose 2 cents a pound on the zinc recovered they would still find this operation profitable in smelting the lead.

Electrolytic spelter is "high grade" in quality. To raise "prime western" spelter to this grade by redistillation involves a loss of about 7 per cent, which, added to the original smelting loss, leaves the recovery at about 82 per cent, compared with about 95 per cent for

electrolytic spelter. The zinc lost in redistillation is not all irretrievably lost, however, for most of it goes into the leady residues, which will probably be sold to lead desilverizers, who can afford to pay for the zinc content.

ZINC-REDUCTION PLANTS.

ELECTROLYTIC ZINC PLANTS.

Electrolytic zinc plants.

Company.	Location of plant.	Daily spelter capacity.	Remarks.
American Smelting & Refining Co.	Omaha, Nebr.	Experimental.	Operated in 1915.
Do.	Murray, Utah.	Experimental.	
Anaconda Copper Mining Co.	Anaconda, Mont.	25 tons.	Under construction; 10 tons operated in 1915.
Do.	Great Falls, Mont.	100 tons.	Under construction.
Bully Hill Copper Co.	Bully Hill, Cal.	Experimental. 10 tons.	Operated in 1915. Under construction.
Colorado Metal Mining & Reduction Co.	Georgetown, Colo.	Ore capacity, 100 tons.	Malm process; under construction.
Electrolytic Zinc Co.	Baltimore, Md.	10 tons.	Under construction in 1915; now in operation.
Judge Mining and Smelting Co.	Park City, Utah.	15 tons.	Under construction.
Mammoth Copper Mining Co.	Kennett, Cal.	Experimental. 25 tons.	Operated in 1915. Under construction.
Northwestern Metals Co.	Helena, Mont.	Ore capacity, 100 tons.	Malm process; completed 1914; never operated.
Reed Zinc Co.	Palo Alto, Cal.	Experimental.	Operated in 1914–15.
River Smelting & Refining Co.	Keokuk, Iowa.	do.	Operated in 1915.

Several experimental electrolytic zinc plants were in operation in 1915, and the Anaconda Copper Co. completed a 10-ton commercial plant and began operating it near the close of the year. The total output of electrolytic spelter for the year was 252 tons. Several other plants of commercial size were completed during the first six months of 1916 and the output for the half year was 1,697 tons primary spelter. A considerable quantity of spelter was electrolytically refined from spelter of ordinary grade and from zinc ashes and skimmings. Both the Anaconda plants, with an aggregate capacity of 125 tons daily, will be in full operation before the close of 1916, and the output of electrolytic spelter should make a good gain during the last half of the year.

ZINC SMELTERS.

The following table gives the zinc-smelting capacity of the United States on December 31, 1915, and June 30, 1916, as well as the retorts under construction or contemplated during the latter half of 1916. Those plants which have an "A" in the column headed "Acid plant" operate sulphuric-acid plants, either at the smelter or elsewhere, as indicated in the footnotes.

Active zinc smelters in the United States and capacity in 1915 and 1916.

[Includes plants working on ore alone, on ore and drosses, and on drosses alone.]

State.	Operating company.	Location.	Acid plant.	Retorts at close of 1915.	Retorts June 30, 1916.	Additional retorts contemplated or under construction.
Arkansas	Fort Smith Spelter Co	Fort Smith			2,560	
Do	Arkansas Zinc & Smelting Corporation.	Van Buren			2,400	
					4,960	
Colorado	United States Zinc Co	Pueblo		2,208	1,944	
Illinois	American Zinc Co. of Illinois	Hillsboro	A	4,000	4,864	
Do	Collinsville Zinc Smelter	Collinsville		1,792	2,304	
Do	Granby Mining & Smelting Co	East St. Louis	A	3,220	3,220	2,400
Do	Hegeler Zinc Co	Danville	A	3,600	5,400	
Do	Illinois Zinc Co	Peru	A	4,640	4,640	800
Do	Matthiesson & Hegeler Zinc Co	La Salle	A	6,168	6,168	
Do	Missouri Zinc Co	Beckemeyer		352	352	
Do	Mineral Point Zinc Co.[a]	Depue	A	9,068	9,068	
Do	National Zinc Co.[b]	Springfield	A	3,200	4,480	
Do	Robert Lanyon Zinc & Acid Co	Hillsboro	A	1,840	3,200	
Do	Sandoval Zinc Co	Sandoval		672	672	
				38,552	44,368	3,200
Kansas	American Spelter Co	Pittsburg		896	992	
Do	American Zinc, Lead & Smelting Co.	Caney		6,080	6,080	
Do	do	Dearing		4,480	4,480	
Do	Chanute Spelter Co	Chanute		1,280	1,280	
Do	Cherokee Smelting Co	Bruce		896	896	
Do	Edgar Zinc Co	Cherryvale		4,800	4,800	
Do	Granby Mining & Smelting Co	Neodesha		3,760	3,760	
Do	Iola Zinc Co	Concreto		660	1,320	
Do	Joplin Ore & Spelter Corporation	Pittsburg		1,444	1,792	
Do	Lanyon Smelting Co	do		448	448	
Do	Owen Zinc Co	Caney		1,280	1,280	640
Do	Pittsburg Zinc Co	Pittsburg		910	910	
Do	Prime Western Spelter Co.[c]	Gas	A	4,868	4,868	
Do	United States Smelting Co	Altoona		3,960	4,600	
Do	do	Iola		3,440	3,440	
Do	do	La Harpe		1,924	1,924	
Do	Weir Smelting Co	Weir				448
				41,126	42,870	1,088
Missouri	Edgar Zinc Co	St. Louis		2,000	2,000	
Do	Missouri Zinc Smelting Co	Rich Hill			448	
Do	Nevada Smelting Co	Nevada		672	672	
				2,672	3,120	
Oklahoma	Bartlesville Zinc Co	Bartlesville		5,184	6,336	
Do	do	Blackwell			1,600	4,800
Do	do	Collinsville		10,752	13,440	
Do	Bartlesville Zinc Co. (Lanyon-Starr plant).	Bartlesville		3,456	3,456	
Do	Eagle-Picher Lead Co	Henryetta				4,000
Do	Henryetta Spelter Co	do			3,000	
Do	J. B. Kirk Gas & Smelting Co	Checotah			2,560	2,560
Do	Kusa Spelter Co	Kusa		3,720	3,720	
Do	La Harpe Spelter Co	do			4,000	
Do	National Zinc Co	Bartlesville		4,970	4,970	
Do	Oklahoma Spelter Co	Kusa			1,600	
Do	Quinton Spelter Co	Quinton				1,340
Do	Tulsa Fuel & Manufacturing Co	Collinsville		6,232	6,232	
Do	United States Zinc Co	Sand Springs		5,680	8,000	
				39,994	58,914	12,700

[a] The Mineral Point Zinc Co. also operates an acid plant at Mineral Point, Wis.
[b] The National Zinc Co. has zinc-roasting furnaces at Argentine, Kans., where the sulphur gases are utilized in an acid plant, the roasted concentrates being shipped to the smelter at Springfield, Ill.
[c] The Prime Western Spelter Co. has roasting furnaces and an acid plant at Tiltonville, Ohio.

Active zinc smelters in the United States and capacity in 1915 and 1916—Continued.

State.	Operating company.	Location.	Acid plant.	Retorts at close of 1915.	Retorts June 30, 1916.	Additional retorts contemplated or under construction.
Pennsylvania	American Zinc & Chemical Co.	Langeloth	A	3,648	6,384	912
Do	Donora Zinc Co., operated by the American Steel & Wire Co.	Donora	A	3,648	9,120	.....
Do	New Jersey Zinc Co. (of Pennsylvania).	Palmerton	.....	6,720	6,960	.....
				14,016	22,464	912
West Virginia	Clarksburg Zinc Co	Clarksburg	.....	3,648	3,648	.....
Do	Grasselli Chemical Co.[a]	....do	A	5,760	5,760	.....
Do	.....do	Meadowbrook	A	8,592	8,592	.....
Do	United Zinc Smelting Corporation	Moundsville	A	.....	.....	6,912
				18,000	18,000	6,912
Total for all States			.....	156,568	196,640	24,812
	Plants with special retorts:[b]					
	Eastern Zinc Refining Co.	Brooklyn, N. Y.	.....	.....	.....	8
	Michael Hayman & Co	Buffalo, N. Y.	.....	12	12	.....
	M. Mooshowitz & Son Metal Co.	Trenton, N. J.	.....	15	15	.....
	Trenton Smelting and Refin- Co.	.....do	.....	96	60	.....
	William Cramp & Sons Ship & Engine Building Co.	Philadelphia, Pa	.....	32	32	.....

[a] The Grasselli Chemical Co. operates acid plants in connection with its zinc-roasting furnaces at Grasselli, Ind., Cleveland, Canton, and Lockland (near Cincinnati), Ohio, and Newcastle, Pa., the roasted zinc concentrates being shipped to the smelters at Clarksburg and Meadowbrook, W. Va.

[b] Large graphite retorts yielding 600–800 pounds of spelter per charge.

In the foregoing list there are a few retort smelters which treat only secondary materials, such as zinc ashes, skimmings, and galvanizers' drosses. There are also a few which recover about equal quantities of spelter from ores and from secondary materials, as well as several more which treat minor quantities of secondary materials. There are several other zinc-smelting plants in the country which obtain spelter by distillation of zinc ashes and drosses in large graphite crucibles and condensers somewhat similar to those used in the Faber du Faur furnaces for recovering zinc from the zinc crusts in lead desilverization. These are given at the bottom of the list.

INCREASE IN SMELTING CAPACITY.

Increase in 1915.—The number of retorts at the beginning of 1915 was 113,914, at the midyear it was 130,642, and at the end 156,568, an increase of nearly 40 per cent in capacity for the year. All available retorts were in active operation and new retorts were put into commission as fast as completed. The large quantity of the higher grades of spelter made by redistillation from the ordinary grades necessitated a greatly enlarged retort capacity, so that the actual output of spelter in itself gives no reliable clue to the number of retorts in use. This Survey has no information of the total number of retorts engaged in redistillation, and hence can not make the usual estimate of the number of retorts effective for smelting ore.

Increase in 1916.—The number of retorts at zinc smelters at the close of 1915 was 156,568, and there were building or planned 49,612 additional retorts, a total of 206,270. The number at smelters June 30, 1916, was 196,640, and 24,812 additional retorts were building or planned, a total of 221,452.

The decline in the price of spelter during May, June, and July caused the temporary closing of some of the smaller smelters and the reduction of operations by several others. A canvass by the Survey showed not over 180,417 retorts in active operation August 15, 1916, out of a possible 199,328. Some of them were being used to treat secondary materials, such as zinc ashes and drosses, and an unknown number of others were engaged in refining the ordinary grade of spelter by redistillation. It will be noted that the number of retorts on August 15 was somewhat larger than that on June 30, owing to the completion of some of those under construction at the earlier date.

TOTAL SMELTER CAPACITY.

On the basis that 156,568 retorts were already in existence at the beginning of 1916, that the 49,612 additional retorts then planned and the electrolytic plants aggregating 60,000 tons in annual capacity, also then planned, were completed, and that the smelters of secondary spelter kept their usual capacity, the United States, as was estimated in the spelter statement of April 4, would have the capacity at the close of 1916 to produce spelter at the rate of more than 900,000 tons a year. This estimate was plainly stated to be one of the capacity under normal or average conditions at the close of the year—in other words, it pertained to capacity which might be exercised during 1917—and it was in no sense an estimate of output for either 1916 or 1917.

It need have occasioned no surprise that the production during the first half of 1916 failed to equal half the capacity indicated for 1917 in the Survey's estimate of capacity. There are evident reasons, of course, why it could not. During the half-year (1916) 25 per cent of the retorts on which the estimate of capacity was based were only under construction or planned; in fact, one-sixth of the 25 per cent had not been completed at the close of the half-year. These could not contribute to the output. Also a very considerable number of retorts was engaged in redistilling spelter of ordinary grade to make it of high grade and so were not operating under normal or usual conditions. These retorts not only did not add to the output of spelter, but they diminished it, because there was a loss of 7 to 10 per cent of zinc in the redistillation. Allowance was made for these factors in the estimate of capacity because it was there considered that the capacity for high-grade electrolytic spelter at the close of 1916 plus the output of high-grade spelter from the lead-free ores of the Eastern States would relieve these retorts of such redistilling.

The average capacity per retort, estimated by the Survey at 4 tons, was somewhat fully considered on pages 892–893 of the chapter on zinc in Mineral Resources, 1914, to which the reader is referred for the data on which the estimate is based. By reason of great demands and high prices it has been claimed that the retorts were so crowded that the ores were "butchered." This, if true, would reduce the percentage of recovery but not the output. Smelters would certainly not crowd the retorts if they would thereby lower

the average total output per retort. In times of great demand it would be expected, rather, that percentage of recovery might be sacrificed to capacity.

It does not seem likely that the grade of ore smelted in 1915 and 1916 was materially lower than in previous years. Practically all zinc sulphide ores are concentrated before being smelted. If the average grade of zinc concentrates was in fact lower it would, of course, lower the average capacity per retort. But zinc smelters, forced by the lack of smelting capacity in 1915, paid a premium for higher-grade concentrates and refused to buy the lower grade. It is improbable that the grade of concentrates from Franklin Furnace or from the East Tennessee zinc mines during 1915–16 was lower. The grade of the small output of Wisconsin carbonates in 1915 was 2½ points lower than in 1914, and that of the green sulphide concentrates was 1½ points higher, but sphalerite concentrates from Wisconsin are mostly re-treated by roasting and magnetic separation, and the average grade as delivered to the smelter is not definitely known, but was higher than in 1914, because a larger part of the ore was roasted and magnetically concentrated before being smelted. In the Joplin district as a whole the average grade of sphalerite concentrates was 0.6 of a point higher, and the grade of carbonates and silicates more than 0.9 of a point higher in 1915 than in1914. The following quotation from J. P. Dunlop,[1] of this Survey, referring to conditions in the Joplin district, is of interest:

> The significant feature of the ore market during the year was the wide margin between the base prices offered for the high and for the medium and lower grades of concentrates. The spread had usually been comparatively small, but in 1915 it was generally $10 to $15 a ton and ferquently the difference was as great as $15 or $20 a ton. This was due to the imperative demand by the smelters for concentrates free from lead or containing less than 1 per cent lead. Some weeks it was difficult to sell the low-grade ore even at the quoted low base price.

Zinc sulphide concentrates from the Butte & Superior mill assayed half a point higher in 1915 than in 1914. The increase of flotation treatment during 1915 must have operated to raise the grade of zinc sulphide concentrates in other Western States. In fact, so far as domestic zinc concentrates are concerned, the grade must have been raised instead of lowered in 1915. But large quantities of zinc concentrates from Australia have been received and treated in 1915–16. If these were sufficiently below the average grade of domestic concentrates to overcome the increase in grade of domestic concentrates, then the average grade of all concentrates may have been lowered. W. R. Ingalls [2] says 848,776 tons of sulphide concentrates and 349,299 tons of carbonate concentrates were smelted in the United States in 1915. Assuming 40 per cent as the average zinc content of the carbonates, 58 per cent as the zinc content of the Joplin sulphides, and 50 per cent as the average zinc content of all other sulphides, we get an average zinc content of 49 per cent for all zinc ores smelted. Ingalls estimates it at 50 per cent. As the Australian concentrates have for several years averaged a little over 47 per cent, and as probably the higher grade concentrates only were brought to the United States in 1915, it does not appear that the Australian imports have materially lowered the general grade of concentrates smelted.

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[1] Dunlop, J. P., U. S. Geol. Survey Mineral Resources, 1915, vol. 1, p. 89, 1916.
[2] Ingalls, W. R., Spelter statistics for 1915: Eng. and Min. Jour., vol. 101, p. 607, 1916.

SMELTER CHANGES IN 1915.

In Pennsylvania the American Zinc & Chemical Co. completed the new plant at Langeloth as planned, with 3,648 retorts, and immediately began construction exactly to double the capacity for both spelter and sulphuric acid. The New Jersey Zinc Co. added 960 retorts at the Palmerton plant. The Donora Zinc Co. began the construction of a large plant at Donora, on the Monongahela River, about 25 miles south of Pittsburgh. The plant will contain 9,600 retorts, with a planned capacity of 40,000 tons a year of spelter and the equivalent quantity of acid. There were 3,648 retorts completed and operating by the close of 1915. The plant was put in partial operation in 104 days from the start of construction, a record in zinc smelter building.

In West Virginia the Clarksburg Zinc Co. doubled its capacity by adding 1,824 retorts. The Grasselli Chemical Co. added 1,680 retorts at Meadowbrook.

In Illinois the Granby Mining & Smelting Co. completed a smelter with 3,220 retorts and commensurate acid department at Rose Lake, a short distance from East St. Louis. The Hegeler Zinc Co., at Danville, doubled smelting and acid capacity from 1,800 to 3,600 retorts. The Matthiesson & Hegeler Zinc Co. added 912 retorts at La Salle. The plant of the Sandoval Zinc Co., at Sandoval, was burned during the year, but rebuilt in time to start before the close of the year.

In Missouri the old coal-fired smelter at Nevada was dismantled early in the year, but was later rebuilt and operated by the Nevada Smelting Co.

In Kansas the J. B. Kirk Gas & Smelting Co. rebuilt several blocks of the old Lanyon smelter at Iola and operated it until June 30, when it was purchased by the United States Smelting Co., which had also purchased, on June 15, the plant of the Altoona Zinc Smelting Co. A new smelter constructed on the site of the old plant of the La Harpe Spelter Co. by the Nicholson Construction Co. was likewise purchased by the United States Smelting Co. Additional retorts were constructed at all three plants, which, at the close of the year, had over 9,000 retorts. The American Zinc, Lead & Smelting Co. added 640 retorts to the plant at Dearing and 2,432 retorts to the plant at Caney, where also the Owen Zinc Co. constructed a plant with 1,280 retorts, which was operated under lease by the American Zinc, Lead & Smelting Co. The Cherokee Zinc Co. reopened the old smelter at Bruce, with 896 retorts, and it was purchased in July by the Cherokee Smelting Co. The Pittsburg Zinc Co. built 448 additional retorts. The Joplin Ore & Spelter Corporation purchased the Cockerill smelter at Pittsburg, rebuilt the furnaces, and replaced the hand roasters by two mechanical roasters. The American Spelter Co. built a plant with 992 retorts, also at Pittsburg, which with four smelters in operation, began to resemble the Pittsburg of the days before natural-gas smelting. The plant of the Chanute Zinc Co. was taken over by the Chanute Spelter Co. The Iola Zinc Co. built a block of 660 retorts at Concreto, 3 miles northeast of Gas.

In Oklahoma the Bartlesville Zinc Co. added 2,688 retorts at Collinsville, the National Zinc Co. added 710 retorts at Bartlesville,

and the United States Zinc Co. added 3,280 retorts at Sand Springs. The Kusa Spelter Co. built a smelter with 3,720 retorts at Kusa, a new town in a gas and coal belt about 5 miles east of Henryetta.

SMELTER CHANGES IN 1916.

Some of the smelters listed as planned early in the year were abandoned, and other plants not listed never got beyond the promotion stage. On the other hand, work was begun on three smelters not listed. Extensive additions were made to plants already in existence. A few notes summarized from the mid-year spelter statement issued August 15, 1916, are given here to record the rapid changes in the industry.

In Pennsylvania the plant of the Donora Zinc Co. was completed and put into full operation. The plant of the American Zinc & Chemical Co. was increased to double its former capacity and a further addition of 912 retorts was begun.

In West Virginia the United Zinc Smelting Corporation, affiliated with the Clarksburg Zinc Co., broke ground at Moundsville in July for a smelter of 6,912 retorts and an acid plant.

In Illinois additional capacity was erected at Hillsboro (by the American Zinc Co. of Illinois and the Robert Lanyon Zinc & Acid Co.), at Collinsville, at Danville, and at Springfield. The Granby Mining & Smelting Co. began an addition of 2,400 retorts at East St. Louis.

In Missouri the old coal-fired smelter at Rich Hill was rebuilt by the Missouri Zinc Smelting Co.

In Kansas another block of 660 retorts was erected by the Iola Zinc Co. at Concreto. Additions were made by the Joplin Ore & Spelter Corporation at Pittsburg, by the Owen Zinc Co. at Caney, and by the United States Smelting Co. at Altoona. At Weir City, the site of the first zinc smelter west of St. Louis, the Weir Smelting Co. built a small coal-fired smelter.

In Oklahoma the Bartlesville Zinc Co. began the erection of a smelter at Blackwell, 1,600 retorts being completed by the middle of the year and 4,800 being under construction. At Henryetta, the Henryetta Spelter Co. completed a 3,000-retort smelter and the Eagle-Picher Lead Co. began the erection of a 4,000-retort plant. At Kusa, the Kusa Spelter Co. doubled its capacity by adding 3,720 retorts, the La Harpe Spelter Co. built a plant of 4,000 retorts, and the Oklahoma Spelter Co. built one of 1,600 retorts. The Quinton Spelter Co. began the erection of 1,340 retorts at Quinton, and the J. B. Kirk Gas & Smelting Co. built a plant with 2,560 retorts at Checotah. Under date of August 15, the United States Smelting Co. traded its plant at Iola, Kans., for the plant at Checotah, and began an addition to double its capacity. The United States Zinc Co. added 2,320 retorts at Sand Springs, and the Bartlesville Zinc Co. added 1,152 retorts at Bartlesville and 2,688 at Collinsville, making the latter by far the largest zinc smelter in the world.

In Arkansas the Fort Smith Spelter Co. built a smelter with 2,560 retorts at Fort Smith, and the Arkansas Zinc & Smelting Corporation erected a plant of 2,400 retorts at Van Buren. Both these plants draw natural gas from a pool in the vicinity of Fort Smith.

The American Zinc, Lead & Smelting Co. took over the Granby Mining & Smelting Co., acquiring mining lands and a lead smelter in Missouri, a natural-gas zinc smelter at Neodesha, Kans., and the new smelter at East St. Louis. For the present, the corporate identity of the Granby Co. is preserved.

The Butte & Superior Mining Co. acquired an interest in the American Zinc, Lead & Smelting Co., and it is reported that plans for their consolidation are maturing.

TRADE CONDITIONS.

WORLD'S PRODUCTION.

Owing to the disturbed conditions in Europe, complete figures of the world's spelter production in 1914 and 1915 can not be given. In the table the fragmentary statistics for those years were obtained from consular reports, official reports, mining journals, or any other source available.

The following spelter statistics prior to 1914, apportioned according to the country where smelted and not according to the source of the ore, are the figures of Henry R. Merton & Co., of London, taken from the annual statistical publication for 1913 of the Metallgesellschaft, the Metallurgische Gesellschaft, A.-G., and the Berg und Metallbank Aktiengesellschaft of Frankfort on the Main, Germany, except that the figures for the United States are those of the United States Geological Survey:

World's production of spelter, 1907–1915, in short tons.

Country.	1907	1908	1909	1910	1911	1912	1913	1914	1915
Australia	1,098	1,198	.....	560	1,904	2,531	4,105	5,616	[a] 7,500
Austria	12,522	14,063	13,931	14,666	18,602	21,609	23,928	.....	.....
Belgium	170,307	181,851	184,194	190,233	215,050	220,678	217,928	.....	.....
France and Spain	61,438	61,512	61,859	65,191	70,791	79,543	78,289	[b] 12,944	[b] 8,497
Germany	230,058	239,062	242,594	251,046	276,008	298,794	312,075	.....	.....
Great Britain	61,286	60,029	65,422	69,531	73,806	63,086	65,197	.....	.....
Holland	16,526	19,107	21,548	23,121	25,059	26,380	26,811	18,098	12,243
Japan	.....	.....	.....	.....	.....	.....	.....	6,554	23,421
Norway	.....	.....	.....	.....	7,363	8,959	10,237	[c] 10,028	[c] 17,349
Russia	10,735	9,740	8,758	9,514	10,952	9,659	8,389	[a] 7,000	.....
United States	249,860	210,424	255,760	269,184	286,526	338,806	346,676	353,049	489,519
	813,830	796,896	854,066	893,046	986,061	1,070,045	1,093,635	.....	.....
United States percentage of world's production	30.7	26.4	29.9	30.1	29.1	31.7	31.7	.....	.....

[a] Estimated. [b] Spain only. [c] Sweden.

PRODUCTION OF SECONDARY SPELTER IN EUROPE.

The following table of the production of secondary spelter in Europe is calculated to short tons from a table published by Rudolf Wolff, Kreuger & Co., of London. It includes the ouptut of the larger regular producers only. The production of the United States is included for comparison.

Secondary spelter produced in Europe and United States, 1905–1913, in short tons.

Country.	1905	1906	1907	1908	1909	1910	1911	1912	1913
Austria-Hungary	3,505	3,674	3,931	3,315	3,102	2,934	3,282	3,282	2,822
Belgium	4,044	4,473	3,620	4,295	3,564	3,406	3,288	4,138	3,366
Denmark	.....	.....	.....	.....	.....	224	1,184	1,353	1,374
France	14,304	14,898	15,130	20,309	20,467	20,691	24,345	25,077	20,490
Germany	9,689	11,040	11,316	13,273	14,943	15,133	16,022	21,093	18,405
Great Britain	7,913	7,644	7,168	8,714	8,454	7,605	9,296	7,963	5,992
Holland	2,268	2,800	2,957	2,923	2,184	2,610	2,722	3,730	2,822
Russia	1,680	.....	1,680	1,680	.....	.....	.....	.....	.....
United States	.....	.....	18,841	16,970	33,040	41,223	40,513	52,251	50,005
	43,403	44,529	64,643	71,479	85,754	93,826	100,652	118,887	105,995

EFFECTS OF THE WAR ON THE ZINC INDUSTRY.

The following tables of exports of zinc and zinc manufactures, repeating in part tables given elsewhere in this report but including figures later than the year to which this report pertains, are segregated here to show the effect of the war on the zinc industry. The tables arranged by six-month periods, including as they do one period before the war began and four periods since the beginning of the war, show very well the exports of zinc in munitions and of zinc for manufacture into munitions abroad. The exports of spelter and sheet zinc rose from less than 1,000 tons in the period before the war to about 70,000 tons in each period since the war began. In some of the exports, such as cartridges and manufactures of zinc and brass, the actual weight of the zinc contained is not known, hence values only can be given. The total value of exports of zinc and articles containing zinc rose from $6,000,000 in the first period to $17,000,000 in the second, $44,000,000 in the third, $70,000,000 in the fourth, and to $177,000,000 in the fifth.

Spelter and sheet zinc exported from the United States, by six-month periods, 1914–1916, in short tons.

Destination.	1914				1915				1916	
	January–June.		July–December.		January–June.		July–December.		January–June.	
	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Foreign.	Domestic.	Foreign.
Canada	.....	167	3,383	539	2,918	382	6,561	203	4,634	638
Great Britain	45	.....	40,802	2,897	31,100	3,477	23,452	1,644	19,188	6,481
Netherlands	.....	.....	.....	.....	.....	.....	12	.....	6	.....
France	.....	.....	8,463	1,902	15,849	1,396	9,406	4,668	18,804	11,177
Italy	.....	.....	1,651	.....	2,717	448	6,051	504	5,807	1,901
Germany	84	.....	.....	.....	.....	.....	.....	.....	.....	.....
Russia	667	.....	4,152	.....	6,671	.....	5,420	.....	3,219	.....
Japan	.....	.....	456	.....	187	.....	470	.....	610	.....
Other countries	34	.....	5,070	75	4,926	1	3,063	997	5,739	.....
	830	167	63,977	5,413	64,368	5,704	54,235	8,016	58,007	20,197

Spelter and sheet zinc exported from the United States, by months, 1914–1916, in short tons.

Month.	1914			1915			1916		
	Domestic.	Foreign.	Foreign zinc used in articles exported with benefit of drawback.	Domestic.	Foreign.	Foreign zinc used in articles exported with benefit of drawback.	Domestic.	Foreign.	Foreign zinc used in articles exported with benefit of drawback.
January	230	28		15,299	84		10,483	3,531	
February	18	.....		15,002	2,016		10,328	3,919	
March	146	.....	1,881	8,120	1,136	255	8,171	575	.....
April	60	.....		8,842	77		9,133	1,902	
May	107	112		7,635	1,104		8,583	4,811	
June	260	27		9,470	1,286		11,309	5,459	
July	157	.....		6,492	1,876		.....	.....	.....
August	3,448	319		7,274	757		.....	.....	.....
September	19,045	1,120	3,100	8,653	2,122	.....	.....	.....	.....
October	10,259	1,140		12,093	608		.....	.....	.....
November	12,747	957		10,019	2,343		.....	.....	.....
December	18,321	1,877		9,704	310		.....	.....	.....
	64,807	5,580	4,981	118,603	13,720	255	58,007	20,197	.....

Zinc exported from the United States by six-month periods, 1914–1916, by classes.

	1914				1915				1916	
	January–June.		July–December.		January–June.		July–December.		January–June.	
	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.	Quantity (pounds).	Value.
DOMESTIC.										
Zinc ore	16,083,200	$275,184	6,137,600	$113,280	1,355,200	$24,791	309,120	$10,485	67,200	$1,792
Spelter and sheets	1,659,858	100,657	127,954,164	8,440,011	128,735,815	11,627,295	108,470,113	17,910,385	116,014,559	20,575,060
Zinc dross	572,477	29,084	4,498,590	211,860	5,863,250	345,387	2,470,263	161,569	56,025	3,080
Zinc manufactures		82,254		128,654		1,047,975		1,125,114		304,452
Brass, old, for remanufacturing	13,535,666	1,437,763	7,103,735	663,107	8,662,272	912,896	2,594,400	346,742	2,568,093	527,884
Brass, bars, plate, and sheets	3,084,938	443,187	4,030,869	465,966	36,251,304	5,683,217	30,020,806	6,752,689	103,085,355	28,917,034
Brass, articles made from		1,862,515		1,894,373		10,924,990		30,192,781		98,110,795
Cartridges		1,896,415		4,670,707		13,043,498		11,771,181		24,718,907
FOREIGN.										
Zinc ore, contents	279,000	5,909								
Zinc, block, pigs, and old	55,118	2,634	10,825,453	209,602	11,406,833	336,099	16,032,910	2,110,571	40,394,341	4,154,127
Zinc dust	34,212	1,775	322,050	15,697	227,408	22,680	204,407	32,707	157,671	29,357
Zinc manufactures		53		18,491		54,124		64,980		1,072
Brass, old, for remanufacturing	12,585	1,586	1,068	135						
Zinc used in articles exported with benefit of drawback	3,761,879	[a] 198,400	6,200,279	[a] 330,500	510,678	[a] 65,000				
		6,337,416		17,162,383		44,087,952		70,479,204		177,343,560

[a] Represents the value of the metal used in making the articles exported with benefit of drawback.

IMPORTS AND EXPORTS.

The following tables of imports and exports of zinc and of zinc remaining in warehouse are made up from the publications and records of the Bureau of Foreign and Domestic Commerce of the Department of Commerce.

WAREHOUSE TRANSACTIONS.

Zinc imported into the United States as metal or in ore may be entered for immediate consumption, in which case the duty is paid and the zinc goes direct to the importer; or it may be entered for warehouse, bond being given for double the amount of the estimated duty. In accordance with the usage of the Bureau of Foreign Commerce, the term "General imports," in the accompanying tables indicates the total zinc imports, including both zinc articles entered for immediate consumption on arrival and zinc articles entered for warehouse, as distinguished from "Imports for consumption," embracing zinc imports entered for immediate consumption and zinc withdrawals from warehouse for consumption. The statement of general imports and the statement of imports for consumption for any period will differ to the extent that the entries for warehouse for the period differ from withdrawals from warehouse for consumption.

From warehouse the zinc ore may be withdrawn for consumption by payment of duty, or it may be exported from warehouse as ore, or it may be smelted in bond, the metal finally being either withdrawn for consumption or exported from warehouse with cancellation of bond. In the table of imports for consumption the imports are expressed in terms under which they were originally entered. The zinc imported for consumption may be actually used in the country or it may be manufactured and exported, in which case the manufacturer is entitled to the benefit of a drawback of 99 per cent of the duties paid. In the table showing foreign zinc exported in manufactures with benefit of drawback the zinc is shown in the form in which it was originally imported, because, on account of diversity of manufactured form, it is not feasible to show the articles actually exported. The foreign zinc given in the table below as exported from warehouse is likewise shown in the form in which it was imported and entered for warehouse. Foreign zinc exported from warehouse has, since July 1, 1915, been included by the Bureau of Foreign and Domestic Commerce in the domestic exports as "from foreign ore."

The items, foreign zinc exported from warehouse, domestic exports of zinc "from foreign ore," and foreign zinc exported in manufactures with benefit of drawback, make up the total foreign zinc going out of the country. For the sake of simplicity this foreign zinc is carried on the records of the bonded customs warehouse in the form in which the zinc was entered until the bond is canceled. It must be clearly understood, therefore, that in the table of foreign exports of zinc, on a later page, the zinc there listed was not exported as zinc content of ore but as spelter smelted from the ore. This had been shown in the Monthly Summary of the Bureau of Foreign and Domestic Commerce since July, 1915, as noted above.

No record is kept of the zinc in the form in which it is actually exported, except for that portion of the articles manufactured from foreign zinc and exported with benefit of drawback. For articles not

wholly made of zinc it would be useless to give weights; but each shipment on which drawback is claimed is accompanied by a manifest of the imported zinc used in making the articles and the duty paid thereon. From these manifests is derived the statement of the total quantity of foreign zinc used in manufactures exported with the benefit of drawback. For this reason the zinc is given in the form in which it was imported.

ZINC REMAINING IN WAREHOUSE.

The following table is taken from the reports of the Bureau of Foreign and Domestic Commerce. For the reasons already given the zinc is shown in the terms in which imported. For instance, a considerable part of the zinc stated as remaining in ore doubtless represents spelter waiting at the bonded zinc smelter for a favorable market for shipment. If this is borne in mind the table gives an idea of the fluctuation of stocks of foreign zinc.

The quantity of zinc remaining in warehouse at the close of the years prior to 1909 has been negligible, but since all zinc ore became dutiable on August 6, 1909, the quantity of bonded zinc has largely increased. The large imports of foreign zinc on account of the demand for munitions greatly swelled the quantity remaining in warehouse December 31, 1915, as will be seen in the accompanying tables.

Practically all the zinc in ore remaining in warehouse prior to 1915 was credited to the port of Kansas City, Mo., and was in possession of the bonded zinc smelters of Kansas and Oklahoma. In 1915 eastern zinc smelters became important consumers of foreign ores, and at the close of the year considerable ore remained in warehouse in that section.

Zinc remaining in warehouse in the United States Dec. 31, 1909–1915.

Year.	Ore and calamine.			Blocks, pigs, and old.		Zinc dust.[a]	
	Short tons.	Zinc content.	Value.	Quantity.	Value.	Quantity.	Value.
		Pounds.		*Pounds.*		*Pounds.*	
1909	2,813	2,255,341	$36,384	78,667	$4,021	.....	.....
1910	2,603	2,572,122	61,730	61,146	3,406	.....	.....
1911	10,177	6,978,098	137,055	63,454	4,049	.....	.....
1912	3,076	2,479,565	62,089	.....	.....	310,715	$18,072
1913	7,531	1,930,425	68,726	.....	.....	291,612	16,008
1914	6,728	6,987,676	90,257	221,994	11,100	272,915	13,005
1915	63,168	43,691,611	1,628,509	63,892	4,028	115,375	8,815

[a] Not separately recorded prior to 1912.

The figures for 1910–1912 are exclusive of the zinc contained in certain other ores entered at New York, as explained later in the discussion of the table of general imports of zinc.

IMPORTS.

Zinc imported and entered for consumption in the United States, 1902–1915.

Year.	Block or pigs.		Sheets.		Old.		Value of manufactures.	Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.		
1902	448	$36,536	68	$8,339	157	$8,299	$32,708	$85,882
1903	202	19,161	129	8,537	163	11,772	10,376	49,846
1904	341	34,211	17	2,230	36	3,247	10,394	50,082
1905	428	46,295	14	1,953	86	5,110	8,253	61,611
1906	1,021	240,632	22	3,236	79	7,647	2,904	254,419
1907	1,709	220,474	52	7,158	122	8,582	8,516	244,730
1908	776	78,160	37	4,570	37	2,014	5,645	90,389
1909	9,419	805,087	117	13,510	238	9,999	6,488	835,084
1910	989	95,410	262	36,641	257	17,549	1,526	151,126
1911	323	38,322	296	55,211	104	8,609	7,981	110,123
1912	10,719	1,239,574	728	102,073	147	13,748	8,489	1,363,884
1913	5,165	565,215	223	43,497	275	17,850	5,474	632,036
1914	195	21,140	277	32,004	388	26,512	4,464	84,120
1915	63	16,864	95	14,407	729	103,294	622	134,565

Zinc dust, zinc oxide, and lithopone imported and entered for consumption in the United States, 1910–1915.

Year.	Zinc dust.		Zinc oxide.				Lithopone.	
			Dry.		In oil.			
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.
1910	1,493	$136,749	3,069	$365,701	197	$30,874	1,863	$99,954
1911	1,713	177,420	2,506	316,972	274	40,494	3,178	166,199
1912	2,736	306,061	2,675	342,985	262	43,168	2,952	153,303
1913	2,368	248,482	3,291	410,493	142	23,663	2,533	152,980
1914	2,004	191,582	2,461	279,642	168	23,196	4,036	277,822
1915	707	137,474	853	148,220	29	5,929	2,126	144,567

General imports of old brass fit only for remanufacture, 1903–1915.

[Average composition about one-third zinc and two-thirds copper.]

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1903	608	$154,260	1910	3,072	$786,684
1904	1,330	310,311	1911	1,803	445,116
1905	4,838	1,169,320	1912	3,298	639,045
1906	6,469	1,891,126	1913	4,363	907,521
1907	3,979	1,344,753	1914	2,565	487,542
1908	1,357	355,335	1915	8,354	1,809,550
1909	2,336	579,454			

Two tables are given below which show the importation of zinc ores. The first one shows the zinc ores imported and entered for consumption under the tariff act of 1909, when different grades of ore bore different duties, and also shows the imports under the tariff act of 1913, which levies an ad valorem duty, thus making one class of all

grades of zinc ore. The other table shows the general imports of zinc by countries. The difference between general imports and imports for consumption has been explained on page 960.

Zinc ore and calamine imported and entered for consumption, 1909–1915.

Year.	Containing less than 10 per cent of zinc (duty, free).		Containing from 10 to 20 per cent of zinc (duty, ¼ cent per pound).		Containing from 20 to 25 per cent of zinc (duty, ½ cent per pound).		Containing 25 per cent or more of zinc (duty, 1 cent per pound).[a]	
	Zinc content (short tons).	Value.	Zinc content (short tons).	Value.	Zinc content (short tons).	Value.	Zinc content (short tons).	Value.
1909[b]	.....	.....	167	$8,690	113	$5,632	4,695	$161,430
1910	16	$698	87	4,053	1,178	25,127	19,961	713,684
1911	39	1,411	189	8,705	564	16,914	3,349	120,756
1912	22	1,141	56	3,045	458	6,734	10,328	433,570
1913	.....	.....	[b] 45	2,067	[c] 309	4,395	[a] 4,093	193,014
1914	.....	.....	.....	.....	.....	.....	5,548	149,503
1915	.....	.....	.....	.....	.....	.....	16,282	1,312,833

[a] Includes all classes after Oct. 4, 1913.
[b] For period July 1–Dec. 31 only.
[c] For period Jan. 1–Oct. 3, 1913; Oct. 4–Dec. 31, included in class "containing 25 per cent or more of zinc."

The statistics of general imports as published by the Bureau of Foreign and Domestic Commerce are based on "consular invoice" or "declaration," which is only a close approximation to actual weights and values. The true weights and values of all dutiable articles are determined when the duties are paid, and the correction is applied as "additions by liquidation" or "deductions by liquidation." On free articles this correction is not made. Prior to 1909 zinc ore was in large part undutiable, and in that part of 1909 prior to August 6 a portion of the imports of zinc ore was free. The correction by liquidation for the dutiable zinc ore imported during 1909–1912 is available, but, owing to special instructions followed in one customs district, to apply the correction by liquidation would result in a considerable duplication of imports. The following figures are taken directly from the Monthly Summary of the Bureau of Foreign and Domestic Commerce without the liquidation correction:

General imports of zinc ore into the United States, 1904–1916.

1904–1912.

Year.	Canada.		Mexico.		Total.	
	Ore (short tons).	Zinc content (short tons).	Ore (short tons).	Zinc content (short tons).	Ore (short tons).	Zinc content (short tons).
1904	.....	.....	2,264	.....	2,264	.....
1905	4,063	.....	18,074	.....	22,137	.....
1906	423	.....	59,991	.....	55,414	.....
1907	1,112	.....	102,005	.....	103,117	.....
1908	7,406	.....	46,351	.....	53,757	.....
1909	10,024	.....	104,826	.....	114,850	.....
1910	4,749	1,922	67,818	23,517	72,626	25,439
1911	2,359	947	36,847	14,986	39,116	15,933
1912	8,015	3,661	35,925	14,206	43,940	17,567

General imports of zinc ore into the United States, 1904–1916—Continued.

1913–1916.

Country.	1913			1914		
	Ore (short tons).	Zinc content (short tons).	Value.	Ore (short tons).	Zinc content (short tons).	Value.
Canada	8,889	3,498	$123,929	11,250	4,467	$143,247
Mexico	17,476	6,160	238,052	20,705	7,663	239,399
Belgium	1,674	1,598	64,970	.....	.....	.....
Germany	1,558	841	55,057	.....	.....	.....
Siberia	1,792	1,397	36,517	.....	.....	.....
Other countries	17	3	157	7	2	97
	31,416	13,497	518,682	31,962	12,132	382,743

	1915			1916 (Jan. 1–June 30).		
Canada	11,992	4,710	$177,868	12,865	5,187	$314,524
Mexico	57,699	17,804	2,130,014	79,663	25,471	3,254,004
France	.....	.....	.....	3,884	1,422	56,542
Spain	.....	.....	.....	38,239	16,006	1,051,315
Italy	5,312	2,125	153,388	7,525	3,283	213,275
French Africa	.....	.....	.....	2,464	1,152	73,564
French East Indies	.....	.....	.....	1,653	746	55,407
China and Hongkong	5,880	2,738	119,913	4,231	2,299	189,526
Japan	1,369	499	77,899	.....	.....	.....
Australia	76,410	29,723	1,843,801	82,775	38,133	2,225,790
Other countries	190	69	7,663	546	208	15,121
	158,852	57,669	4,510,546	233,845	93,907	7,449,068

The foregoing figures showing imports of zinc ore in 1910 do not include 10,431 short tons of ore that carried 2,645,111 pounds of zinc as an accessory constituent, an average of less than 13 per cent. which was lost in smelting the ore, and hence for the purpose of this report can not be classed with zinc ore imports, so long as the present metallurgical treatment of that ore prevails. Similarly, the figures for 1911 are exclusive of 25,769 tons of other ore, carrying 6,283,437 pounds of zinc, and those for 1912 are exclusive of 18,245 tons of other ore, carrying 4,862,508 pounds of zinc. The duties on the zinc contents of this ore have since been refunded and the bonds canceled. The ore was shipped from South American ports and largely entered through the port of New York. It is shown in the Monthly Summary of the Bureau of Foreign and Domestic Commerce under the heading of "Merchandise remaining in warehouse," mostly at New York. Such ores have entered free and have not been enumerated since 1912.

EXPORTS.

DOMESTIC EXPORTS.

The practice of the Bureau of Foreign and Domestic Commerce is to class all exports of zinc articles made in this country as domestic exports, whether the zinc be of domestic or foreign origin. Hence, the following table of domestic exports is duplicated in part in a later table of foreign zinc in manufactures exported with benefit of drawback. The exports of zinc ore in the table below are of domestic

origin and in recent years have all been from one mine in New Jersey. The exports of plates, sheets, pigs, or slabs are likewise probably wholly domestic, since, as shown later, all the zinc in manufactures going out under drawback came in as blocks, pigs, and sheets, and the only manufacturing process which would put any of these into the class of exports referred to is rolling into sheets. But the zinc rolling mills in this country do not use foreign spelter. Hence, the conclusion that the plates, sheets, pigs, and slabs of the table are of domestic origin. The zinc dross exports are, no doubt, in part of foreign origin, but in what proportion can not be determined. However, they are not duplicated in the drawback table. The exports of manufactures, of which the value is given, include the value of the whole of the manufactures exported with benefit of drawback, as well as whatever manufactures of domestic zinc may be exported.

Domestic zinc ore and domestic manufactures of zinc exported from the United States, 1902–1915.

Year.	Zinc ore.		Plates, sheets, pigs, or slabs.		Zinc dross.[a]		All other manufactures.[b]	Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Value.	
1902....	55,733	$1,449,104	3,237	$300,557	.....	.....	$114,197	$1,863,858
1903....	39,411	987,000	1,521	163,379	.....	.....	71,354	1,221,733
1904....	35,911	905,782	10,147	1,094,490	.....	.....	117,957	2,118,229
1905....	30,946	848,451	5,516	682,254	.....	.....	159,995	1,690,700
1906....	27,720	733,300	4,670	583,526	15,887	$1,103,706	204,269	2,624,801
1907....	c 20,352	579,490	563	75,194	9,593	560,944	186,203	1,401,831
1908....	c 26,108	877,745	2,640	250,254	8,405	467,403	88,485	1,683,887
1909....	c 12,455	412,300	2,566	263,010	7,069	477,112	69,751	1,222,173
1910....	c 19,711	649,425	3,990	426,560	4,729	380,950	101,336	1,558,271
1911....	c 18,281	642,884	6,872	810,099	4,246	348,176	134,518	1,935,677
1912....	c 23,349	823,997	6,634	864,292	205	17,985	140,027	1,846,301
1913....	c 17,713	631,991	7,783	955,667	28	1,457	145,984	1,735,099
1914....	c 11,110	388,464	64,807	8,540,668	2,526	240,944	210,974	9,381,050
1915....	c 832	35,276	118,603	29,537,680	4,167	506,956	2,173,089	32,253,001

[a] Nor separately enumerated prior to 1906.
[b] Not including brass.
[c] The exports consisted wholly of high-grade willemite ore from New Jersey.

Zinc oxide exported from the United States, 1902–1915.

Year.	Quantity (short tons).	Value.	Year.	Quantity (short tons).	Value.
1902	5,358	$433,722	1909	14,846	$1,026,377
1903	7,215	578,215	1910	13,167	943,938
1904	8,157	628,494	1911	14,618	1,051,311
1905	11,280	810,203	1912	17,064	1,247,702
1906	15,578	1,149,297	1913	14,467	1,136,257
1907	13,257	1,069,924	1914	15,592	1,408,525
1908	12,008	845,070	1915	19,989	2,068,428

Domestic brass and brass manufactures exported from the United States, 1910–1915.

[Zinc content approximately 30 per cent by weight.]

Year.	Bars, plates, and sheets.		Scrap and old.		Articles made from (value).	Total value.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.		
1910						$5,103,865
1911						7,370,088
1912	14,435	$3,090,833	3,431	$1,058,560	$5,036,197	9,185,590
1913	10,943	2,292,349	3,056	933,949	4,719,119	7,945,417
1914	10,320	2,100,870	3,558	909,153	3,756,888	6,766,911
1915	33,136	12,435,906	5,628	1,259,638	41,117,771	54,813,315

This table does not include all the brass exported in munitions. For instance, the large exports of shrapnel are included by the Bureau of Foreign and Domestic Commerce under "All other explosives," which increased in value from $651,601 in 1913 to $89,114,134 in 1915 and to $173,185,180 in the first six months of 1916.

FOREIGN EXPORTS.

By foreign zinc exports is meant the exports of zinc of foreign origin which has been smelted or manufactured in this country and then shipped abroad. The following table, made up from the records of the Bureau of Foreign and Domestic Commerce, shows the total zinc exported from warehouse during the last 10 years—the exports prior to that period being of insignificant proportions—and also the foreign zinc exported in manufactures with benefit of drawback for the same period. These two items—foreign zinc exported from warehouse and foreign zinc in manufactures exported with benefit of drawback—make up the total foreign zinc going out of the country. Zinc in warehouse and deductions by liquidation being disregarded, the difference between the sum of these two exports of zinc and the total imports of zinc constitutes the foreign zinc consumed in this country. It must be clearly understood in regard to this table that the zinc was not exported as zinc content of ore and blocks, pigs, etc., but as zinc smelted or manufactured from them. The reason for this is that the zinc in bonded customs warehouse is carried on the records until the bond is canceled in the same form in which the zinc was entered for warehouse. The zinc content of the foreign ore is, of course, exported as spelter and manufactures of zinc. In the Monthly Summary of the Bureau of Foreign and Domestic Commerce since July 1, 1914, the exports of foreign zinc have been wholly classed as spelter—that is, as "blocks, pigs, and old."

Under present customs regulations zinc equivalent in quantity to the total recoverable zinc content must be exported to secure cancellation of bond. The quantities of zinc exported from warehouse are exact, but the quantities as given of zinc exported in manufactures under drawback are subject to wastage in manufacturing.

Except for a portion of the articles manufactured from foreign zinc and exported with benefit of drawback, no record is kept of

the form in which the zinc is actually exported. Unless the zinc is the constituent of chief value, the actual quantity of zinc is not recorded. But each shipment on which drawback is claimed is accompanied by a manifest of the imported zinc which was used in making the articles, as well as the duty paid thereon. From these manifests is made up the statement of the total quantity of foreign zinc which went into manufactures exported with benefit of drawback, and for this reason the zinc is given in the form in which it was imported.

Foreign zinc exported from the United States in 1905–1915.

Year.	Exported from warehouse.					Exported in manufactures with benefit of drawback.
	Ore and calamine, zinc contents.[a]		Blocks, pigs, and old.		All other manufactures.	Blocks, pig, sheets, and all other manufactures.
	Quantity (short tons).	Value.	Quantity (short tons).	Value.	Value.	Quantity (short tons).
1905	.....	.....	19	$816	$1,015	.....
1906	.....	.....	1	252	1,962	2
1907	.....	.....	9	1,023	1,504	1,555
1908	.....	.....	8	964	4,635	1,234
1909	328	$6,429	6	752	521	.....
1910	4,710	182,345	47	4,884	1,121	4,486
1911	10,818	476,233	458	21,141	2,701	3,079
1912	6,778	306,726	48	4,346	30,649	1,219
1913	5,406	214,437	620	66,919	6,231	7,459
1914	140	5,909	5,440	212,236	18,544	9,506
1915	.....	.....	13,720	2,446,970	119,104	255

[a] After Aug. 6, 1909.

CONSUMPTION.

In the following tables, showing the consumption of spelter in the United States and in the world for the period 1898–1913, the figures of foreign consumption are computed from statistics published by the Metallgesellschaft for 1913. In those statistics consumption is calculated on the basis of production plus excess of imports over exports or minus excess of exports over imports, and altogether disregards smelter stocks. For the sake of comparison the consumption of the United States is calculated by both methods. Although in the long run the stocks carried over from one year are consumed in the next, and thus are equalized, it can not be gainsaid that for the individual year to take stocks into account gives greater accuracy. To obtain perfectly accurate figures of consumption, it would be necessary to consider the stocks in the hands of consumers and dealers and to take into account the secondary spelter consumed. No figures of foreign consumption in 1914 and 1915 are available.

Primary spelter consumed in the United States, 1909–1915, in short tons.

	1909	1910	1911	1912	1913	1914	1915
Supply:							
Stock Jan. 1—							
In bonded warehouses	9	39	31	32	48	.....	111
At smelters	19,613	11,167	23,201	9,049	4,474	40,659	19,984
Production	255,760	269,184	286,526	338,806	346,676	353,049	489,519
Imports	9,454	1,960	609	11,115	6,100	880	904
Total available	284,836	282,350	310,367	359,002	357,298	394,588	510,518
Withdrawn:							
Exports, foreign, from warehouse	334	4,758	11,276	6,286	6,027	5,580	13,720
Exports, foreign, under drawback	.....	4,486	3,079	1,219	7,459	4,981	255
Exports, domestic	2,566	3,990	6,872	6,634	7,783	64,807	117,796
Stock Dec. 31—							
In bonded warehouses	39	31	32	48	.....	111	32
At smelters	11,167	23,201	9,049	4,474	40,659	19,984	14,221
Total withdrawn	14,106	36,466	30,308	18,661	61,928	95,463	146,024
Apparent consumption	270,730	245,884	280,059	340,341	295,370	299,125	364,494

In considering the consumption of primary spelter there should be borne in mind the rapidly increasing quantity of secondary material, such as zinc skimmings, ashes, hard zinc, and scrap zinc, from which zinc is recovered in the form of spelter, alloy, pigment, or chemical, and so used again, thus affecting the consumption of primary spelter. The total quantity of secondary zinc recovered in 1915, so far as there is available record, was 108,758 tons, as compared with 84,607 tons in 1914. For details of the recovery of secondary zinc in 1915 and previous years, see page 856.

The domestic consumption of spelter of foreign origin, both that made in this country from foreign ore and that imported directly as spelter, is a matter of much importance to American zinc producers and smelters. The following table gives this consumption of foreign spelter for the period from 1909 to date. A certain portion of the stocks reported by the smelters as on hand at the close of the year must consist of spelter made from foreign ores, and this has not been taken into consideration in the table, but although this would affect the consumption for any single year it will not impair the usefulness of a table covering the length of time here given.

Foreign zinc consumed in United States, 1909–1915, in short tons.

	1909	1910	1911	1912	1913	1914	1915
Supply:							
Produced from foreign ore	25,535	16,705	14,905	14,899	9,424	9,631	31,384
Stocks in bonded warehouse	9	39	31	32	48	.....	111
Imports	9,454	1,960	609	11,115	6,100	880	904
Total supply	34,998	18,704	15,545	26,046	15,572	10,511	32,399
Withdrawn:							
Exports from warehouse	334	4,758	11,276	6,286	6,027	5,580	13,720
Exports under drawback	.....	4,486	3,079	1,219	7,459	4,981	255
Stocks in warehouse	39	31	32	48	.....	111	32
Total	373	9,275	14,387	7,553	13,486	10,672	14,007
Consumption of foreign zinc	34,625	9,429	1,158	18,493	2,086	*a*—161	18,392

a The excess of withdrawals over supply may be accounted for by exports under drawback of articles manufactured from zinc imported prior to 1914.

World's consumption of spelter, 1907–1913, in short tons.

[Stocks disregarded except in the United States.]

Country.	1907	1908	1909	1910	1911	1912	1913
Austria-Hungary	34,171	35,925	36,155	37,258	47,950	51,588	44,533
Belgium	60,627	74,936	71,209	84,326	81,240	85,098	84,216
France	76,720	85,956	73,744	62,059	90,389	90,389	89,286
Germany	192,792	198,580	207,343	196,320	241,734	248,899	255,734
Great Britain	154,653	152,627	171,408	195,989	193,674	204,146	214,508
Holland	4,189	4,189	4,409	4,409	4,409	4,409	4,409
Italy	7,496	9,257	9,039	8,929	11,133	11,795	12,015
Russia	19,290	19,946	20,282	27,447	31,856	30,754	36,707
Spain	5,180	5,512	4,960	4,630	5,291	5,181	6,503
Other countries	13,228	11,020	9,921	13,668	19,621	21,715	23,038
United States	226,969	214,167	270,730	245,884	280,059	340,341	295,370
	795,315	812,115	879,200	880,919	1,007,356	1,094,315	1,066,319

USES OF ZINC.

The chief use of zinc in the United States in the past has been for galvanizing. For several years figures of the consumption of spelter for different purposes were published by the Engineering and Mining Journal. The figures for 1910, the last published, gave 60 per cent of the spelter output as used in galvanizing, 20 per cent as used in making brass, 11 per cent as rolled into sheet zinc, 1 per cent for the desilverization of lead, and 8 per cent for all other purposes. During 1915 and 1916 the percentage of the total output used in galvanizing must have been less than 60 per cent for the production was much greater, and there was an actual decrease in certain lines of galvanizing, as is shown in the table below. The quantity of spelter used in making brass was very much larger than ever, and it is probable that the percentage of the total output so used was also greater than in 1910. The following figures give an idea of the relative quantity of spelter used in galvanizing certain products for which statistics were collected. Data are not at hand to show the actual percentage of the total weight contributed by the zinc coating.

Galvanized iron and steel sheets, formed products, and tubes produced in the United States, 1913–1915, in short tons.[a]

	1913	1914	1915
Galvanized iron and steel sheets	922,932	903,834	790,785
Galvanized form products[b]	64,595	65,802	56,096
Galvanized tubes	298,973	296,832	314,657
	1,286,500	1,266,468	1,161,538

[a] From annual statistical reports of American Iron and Steel Institute.
[b] Articles formed or stamped from iron or steel sheets and galvanized after shaping.

This table does not include galvanized wire and galvanized cast or wrought iron or steel articles. The production of galvanized wire must have increased greatly, for the exports of wire were very large in 1915 and 1916 as shown in the table below taken from the Monthly Summary of the Bureau of Foreign and Domestic Commerce. It is generally understood that the barbed wire used in military entanglements is galvanized; in fact, a large percentage of the wire exported is galvanized.

Domestic wire exported from the United States, 1913–1916, in short tons.

	1913	1914	1915	1916 (8 months).
Barbed wire	91,897	105,108	278,454	335,456
All other wire	121,222	97,465	251,964	210,787
	213,119	202,573	530,418	546,243

CUSTOMS DUTIES ON ZINC.

TARIFF OF 1909 AND OF 1913.

The tariff act of 1909 had the following sections relating to zinc ore, zinc, and to compounds containing zinc:

PAR. 55. Zinc, oxide of, and white pigment containing zinc, but not containing lead, dry, one cent per pound; ground in oil, one and three-fourths cents per pound; sulphid of zinc, white, or white sulphide of zinc, one and one-fourth cents per pound; chloride of zinc and sulphate of zinc, one cent per pound.

PAR. 193. Zinc-bearing ore of all kinds, including calamine, containing less than ten per centum of zinc, shall be admitted free of duty; containing ten per centum or more of zinc, and less than twenty per centum, one-fourth of one cent per pound on the zinc contained therein; containing twenty per centum or more of zinc and less than twenty-five per centum, one-half of one cent per pound on the zinc contained therein; containing twenty-five per centum of zinc, or more, one cent per pound on the zinc contained therein: *Provided*, That on all importations of zinc-bearing ores the duties shall be estimated at the port of entry, and a bond given in double the amount of such estimated duties for the transportation of the ores by common carriers bonded for the transportation of appraised or unappraised merchandise to properly equipped sampling or smelting establishments, whether designated as bonded warehouses or otherwise. On the arrival of the ores at such establishments they shall be sampled according to commercial methods under the supervision of Government officers, who shall be stationed at such establishments, and who shall submit the samples thus obtained to a Government assayer, designated by the Secretary of the Treasury, who shall make a proper assay of the sample and report the result to the proper customs officers, and the import entries shall be liquidated thereon, except in case of ores that shall be removed to a bonded warehouse to be refined for exportation as provided by law. And the Secretary of the Treasury is authorized to make all necessary regulations to enforce the provisions of this paragraph.

PAR. 194. Zinc in blocks or pigs and zinc dust, one and three-eighths cents per pound; in sheets, one and five-eighths cents per pound; in sheets coated or plated with nickel or other metal or solutions, one and three-fourths cents per pound; old and worn-out, fit only to be remanufactured, one cent per pound.

The tariff act of 1913 substituted ad valorem rates for specific duties and made the provision for smelting in bond applicable to all other metals as well as lead. The paragraphs relating to the various dutiable forms of zinc are as follows:

162. Zinc-bearing ores of all kinds, including calamine, 10 per centum ad valorem upon the zinc contained therein: *Provided*, That on all importations of zinc-bearing ores the duties shall be estimated at the port of entry, and a bond given in double the amount of such estimated duties for the transportation of the ores by common carriers bonded for the transportation of appraised or unappraised merchandise to properly equipped sampling or smelting establishments, whether designated as bonded warehouses or otherwise. On the arrival of the ores at such establishments they shall be sampled according to commercial methods under the supervision of Government officers, who shall be stationed at such establishments, and who shall submit the samples thus obtained to a Government assayer, designated by the Secretary of the Treasury, who shall make a proper assay of the sample and report the result to the proper customs officers, and the import entries shall be liquidated thereon, except in case of ores that shall be removed to a bonded warehouse to be refined for exportation as provided by law. And the Secretary of the Treasury is authorized to make all necessary regulations to enforce the provisions of this paragraph.

163. Zinc in blocks, pigs, or sheets, and zinc dust; and old and worn-out zinc fit only to be remanufactured, 15 per centum ad valorem.

61. Zinc, oxide of, and pigments containing zinc but not containing more than 5 per centum of lead, ground dry, 10 per centum ad valorem; when ground in or mixed with oil or water, lithophone and white sulphide of zinc, 15 per centum ad valorem.

62. Zinc, chloride of and sulphate of, ½ cent per pound.

N. SUBSECTION 1. That the works of manufacturers engaged in smelting or refining, or both, of ores and crude metals, may upon the giving of satisfactory bonds be designated as bonded smelting warehouses. Ores or crude metals may be removed from the vessel or other vehicle in which imported, or from a bonded warehouse, into a bonded smelting warehouse without the payment of duties thereon and there smelted or refined, or both, together with ores or crude metals of home or foreign production: *Provided*, That the bonds shall be charged with the amount of duties payable upon such ores and crude metals at the time of their importation, and the several charges against such bonds may be canceled upon their exportation or delivery to a bonded manufacturing warehouse established under paragraph M of this section of an amount of the same kind of metal equal to the actual amount of dutiable metal producible from the smelting or refining, or both of such ores or crude metals as determined from time to time by the Secretary of the Treasury: *And provided further*, That the said metals so producible, or any portion thereof, may be withdrawn for domestic consumption, or transferred to a bonded customs warehouse, and withdrawn therefrom, and the several charges against the bonds canceled upon the payment of the duties chargeable against an equivalent amount of ores or crude metals from which said metal would be producible in their condition as imported: *And provided further*, That on the arrival of the ores and crude metals at such establishments they shall be sampled and assayed according to commercial methods under the supervision of Government officers, to be appointed by the Secretary of the Treasury and at the expense of the manufacturer: *Provided further*, That antimonial lead produced in said establishments may be withdrawn for consumption upon the payment of the duties chargeable against it as type metal under existing law and the charges against the bonds canceled in a similar sum: *Provided further*, That all labor performed and services rendered pursuant to this section shall be under the supervision of an officer of the customs, to be appointed by the Secretary of the Treasury, and at the expense of the manufacturer: *Provided further*, That all regulations for the carrying out of this section shall be prescribed by the Secretary of the Treasury.

TREASURY DECISIONS.

A decision of the Treasury Department (T. D. 34280, Mar. 16, 1914) provides that ores containing zinc but no other recoverable metal shall be appraised at the price of the ore; that ores containing zinc in quantities not commercially recoverable shall be appraised as of no value; and that ores containing zinc and other metal, both zinc and other metal being commercially recoverable, shall be appraised (for the zinc duty) on the zinc content at the cost of spelter in the United States, making allowance for cost of transportation, duty, profit, smelting, and overhead expenses.

Another decision of the department (T. D. 35216, Mar. 10, 1915) provides for the establishment and regulation of bonded smelting and refining warehouses and extends these provisions to bonded zinc smelters.

The United States Board of General Appraisers rendered a decision (T. D. 35948, Nov. 30, 1915) in the protest of the National Zinc Co. that affirmed the assessment of additional duty and penalty by the collector of customs at the port of St. Louis on zinc ore undervalued upon entry.

The Treasury Department has issued the following letter of instructions to appraisers of merchandise (T. D. 36446):

APPRAISEMENT OF ZINC ORE.

Method of ascertaining the value of zinc in imported ore under the provisions of paragraph L of section 3, tariff act of 1913, based upon the selling price of zinc in the United States.

TREASURY DEPARTMENT, *June 3, 1916.*

To appraisers of merchandise and others concerned:

The following method will be followed by appraising officers in determining the value of zinc in imported ore arriving in the United States after July 1, 1916:

(1) From the ascertained assay deduct 8 units for sulphide and 6 units for nonsulphide ores. The remainder will represent percentage of recoverable zinc in the ore, which multiplied by 2,000 will give the number of pounds of zinc recoverable from a ton of ore.

(2) Multiply the result as above ascertained by the average price of prime western spelter at East St. Louis for the week in which the ore was exported; that is, the week including the date of sailing of the ship or day the car leaves the foreign country. This will give the gross value of the zinc in the ore at the time of its exportation.

(3) Deduct from the gross value of the zinc in the ore as above ascertained the following:

(*a*) The freight actually paid from the foreign mine to the domestic smelter receiving same in the United States.
(*b*) The insurance actually paid.
(*c*) The actual shipping charges.
(*d*) Foreign export duties and charges, if any.
(*e*) Treatment charge (as explained in par. 4).
(*f*) Penalties for iron, as stipulated in paragraph 5.
(*g*) Duty on lead contents, if any.
(*h*) Duty on zinc.

(4) *Treatment charge.*—(*a*) For sulphide ores the treatment charge will be ascertained as follows: From the value of the recoverable spelter in a ton of 2,000 pounds medium grade Joplin sulphide ore, 60 per cent base, deduct the average of the quoted prices for such ore and $1.50 per ton of 2,000 pounds as representing the average freight on Joplin ores from Joplin, Mo., to common Kansas smelting points.

(*b*) For nonsulphide ores the treatment charge will be ascertained as follows: From the value of the recoverable spelter in a ton of 2,000 pounds of 40 per cent calamine ore deduct the average of the quoted prices for such ore and $1.50 per ton of 2,000 pounds as representing the average freight paid from Joplin, Mo., to common Kansas smelting points.

(5) *Penalties.*—On iron ore deduct penalties as follows: $1 on each unit of iron in excess of 1 per cent up to and including 6 per cent; $0.50 per unit on each unit of iron in excess of 6 per cent up to and including 12 per cent; $0.25 for each unit of iron in excess of 12 per cent.

(6) The average market price of Joplin zinc ore and prime western spelter to be taken in accordance with quotations contained in the Engineering and Mining Journal for the calendar week, including the date of the sailing of the ship or day the car leaves the foreign country.

(7) Recoverable spelter, wherever that term is used in this memorandum, means for sulphide ores the assay minus eight units, and for nonsulphide ores the assay minus six units.

EXAMPLE.—*Sulphide ore.*

Assume: Assay 48 per cent zinc, 6 per cent lead, 14 per cent iron; freight, mine to smelter, $13 per ton of 2,000 pounds; insurance, $0.50 per ton; loading and expenses, $1 per ton; prime western spelter, 15 cents per pound; medium grade Joplin ore, 60 per cent base, $100 per ton.

48% − 8% = 40% × 2,000 lbs. = 800 lbs. at 15¢		$120.00
Deductions:		
Freight, mine to smelter	$13.00	
Insurance	.50	
Loading and expense	1.00	
		$14.50
Penalties:		
14% − 1% = 13%.		
5% at $1.00	5.00	
6% at .50	3.00	
2% at .25	.50	
		8.50

Treatment:

60%−8%=52%×2,000=1,040 at 15¢		$156.00	
Ore quotation	$100.00		
Freight to smelter	1.50		
		101.50	
		$54.50	
Lead, 2,000 lbs.×6%=120 lbs., at ¾¢		.90	
			$78.40
			41.60

$41.60÷$1.10=$37.82 dutiable value.

EXAMPLE.—*Nonsulphide ore.*

Assume: Assay 36 per cent zinc, 3 per cent lead, 2 per cent iron; freight, mine to smelter, $10 per ton of 2,000 pounds; export duty, $1; prime western spelter, 15 cents per pound; Joplin calamine, 40 per cent base, $50 per ton.

36%−6%=30%×2,000 lbs.=600 lbs., at 15¢			$90.00
Deductions:			
Freight, mine to smelter	$10.00		
Export duty	1.00		
		$11.00	
Iron penalty, 2%−1%=1% at $1.00		1.00	
Treatment:			
40%−6%=34%×2,000 lbs.=680 lbs., at 15¢		102.00	
Ore quotation	$50.00		
Freight to smelter	1.50		
		51.50	
		50.50	
Lead duty (not over 3%, no duty)			62.50
			27.50

$27.50−$1.10=$25 dutiable value.

Owing to the fact that the several factors necessary to determine the market value or purchase price of zinc ores are usually not known at the time of shipment, and importers can not ascertain the value of the zinc in the ore, collectors are authorized to permit entry by appraisement of zinc-bearing ores.

ANDREW J. PETERS,
Assistant Secretary.

The following modification (T. D. 36652) of these instructions was also sent out by the department:

TREASURY DEPARTMENT, *August 31, 1916.*

To appraisers of merchandise and others concerned:

The plan for the appraisement of zinc in ore, published in T. D. 36446, is hereby modified, to provide that the method therein set forth shall not apply to sulphide ores assaying 40 per cent or less of zinc. The zinc in such ores should be appraised at not less than the contract or purchase price.

ANDREW J. PETERS,
Assistant Secretary.

PRICES AND VALUE.

PRICES.

Spelter opened at St. Louis in January at 5.5 cents a pound and immediately began the long rise, which except for one considerable setback in March and a smaller one in May continued until June 4, when spelter reached 26.5 cents a pound. A sharp drop immediately carried the price down to 17.75 cents by June 22, after which it recovered to 22.75 cents by July 9. Another sharp break let the price go down to 10.75 cents in the middle of August. Several ups and downs followed, after which the price rose to 19 cents in the latter part of November. A sharp decline carried the price down to

15 cents at the middle of December. A rapid recovery followed, and spelter closed the year at about 17.25 cents a pound. The average price for the year of prime western spelter at St. Louis was 14.2 cents a pound, as compared with 5.1 cents in 1914 and 5.6 cents in 1913.

The London spelter market opened at £28 2s. 6d. a long ton (6.1 cents a pound) and, nearly paralleling the American market, rose to £110 a long ton (23.8 cents a pound) in the middle of June, dropped to £55 a long ton (11.9 cents a pound) in August, rose to £105 a long ton (22.7 cents a pound) in November, and closed the year at £90 a long ton (19.5 cents a pound). In the first nine months of the year the London price was sometimes below and sometimes above the American price, but from October onward the London price was consistently the higher, in November and December averaging nearly 2 cents a pound more than the St. Louis price.

According to the London Mining Journal, the highest previous prices within 100 years were £41 10s. a long ton (8.9 cents a pound) in 1825 and £40 a long ton (8.7 cents a pound) in 1840.

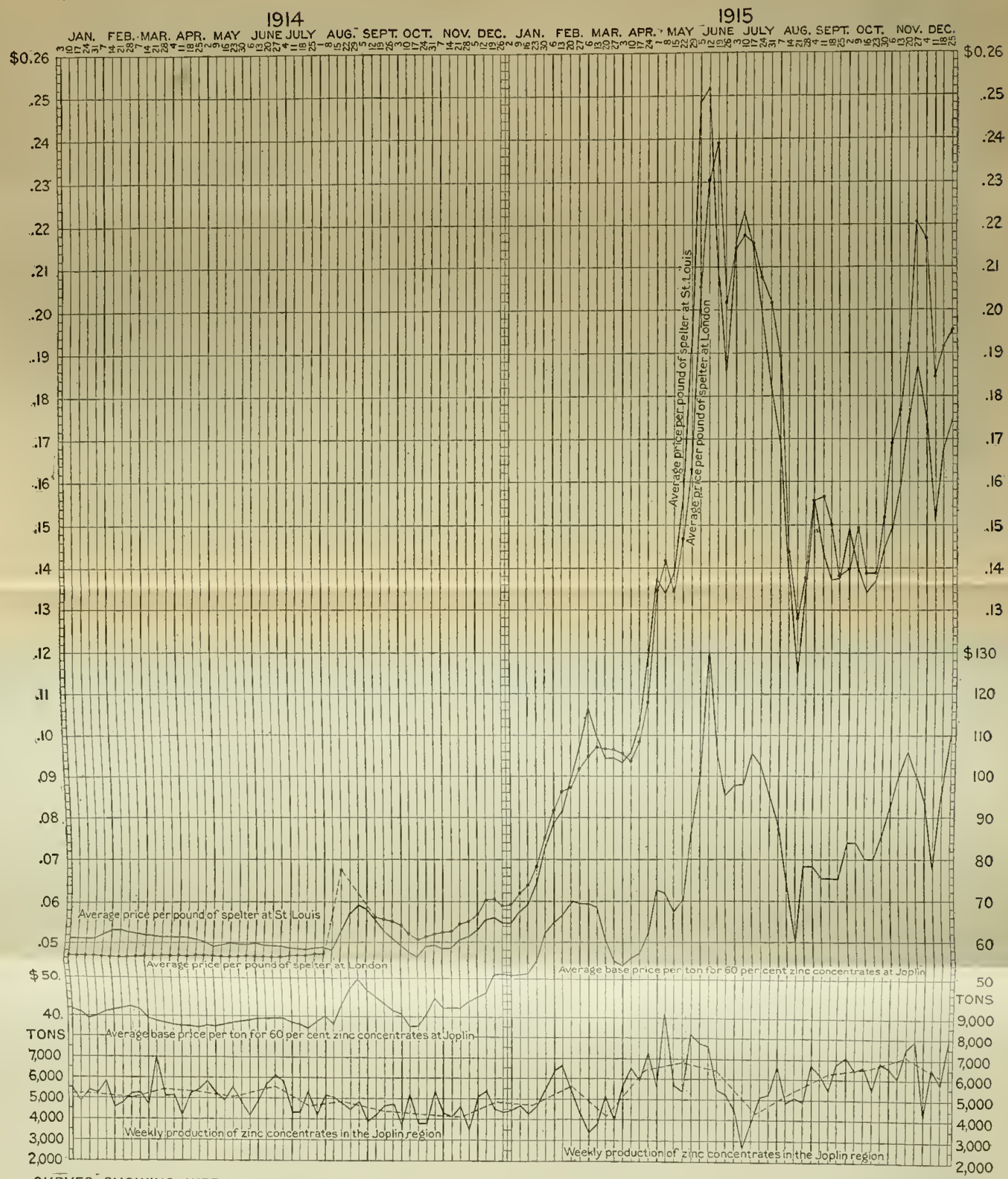
The price of the "brass special" grade of spelter at Waterbury, Conn., usually averages about 0.4 cent above the St. Louis price. During 1915, however, the differential ranged from 2.5 to nearly 5 cents, averaging about 3.3 cents. The price of the highest grades of spelter is not quoted, but sales are reported at more than 40 cents a pound when spelter was at the high point.

The price of sheet zinc generally ranges from 2 to 2.5 cents above the St. Louis price of spelter. During 1915 sheet zinc has varied from 2.5 to 8.75 cents above the price of spelter.

Zinc dust, heretofore mostly imported from Europe, generally ranges from 1 to 2 cents a pound higher than spelter. In March, 1915, the price of zinc dust began to go up, and in the first two weeks of June it more than doubled, jumping from 17 cents to 40 cents. There was a decline of a few cents, but by the last week in July the price had settled back to 38 to 40 cents per pound, at which it has since remained.

VALUE.

In the Survey's New Year estimate of the production of spelter in 1915 the value of the output was calculated from the yearly average of the prices quoted in St. Louis for prime western spelter for immediate delivery, and the statement was made that the real value was probably from 10 to 25 per cent higher than the figures given, because a considerable part of the sales represented the better grades—brass special, intermediate, and especially high-grade spelter—all of which commanded premiums, high-grade spelter selling at times for nearly double the quoted price of prime western spelter. This statement immediately brought the comment from producers that because spelter was largely sold for future delivery at 1 to 3 cents a pound less than the prices quoted for immediate delivery, the average price received for all grades was probably under rather than over the average price quoted for immediate delivery. To settle this very interesting question each producer was asked to give the average price at which his output was sold. From these returns, which were received from every producer, the average selling price for 1915 for all grades



CURVES SHOWING WEEKLY AVERAGE PRICES OF SPELTER AT LONDON AND ST. LOUIS AND OF ZINC CONCENTRATES AT JOPLIN, ALSO WEEKLY PRODUCTION OF ZINC CONCENTRATES IN THE JOPLIN REGION IN 1914-15.

The broken line shows the weekly sales, averaged by months.

was determined at 12.4 cents a pound, as compared with 14.2 cents a pound, the average quoted price for prime western spelter for immediate delivery. It is thus shown, as was in fact intimated in the trade journals, that the output of the smelters was generally sold up for two, three, or more months in advance. It is also shown that the real value, instead of being 10 to 25 per cent above the value calculated from the average price quoted, as stated in the New Year estimate, was in fact about 13 per cent below that value.

The production of primary spelter from domestic ores in 1915 was 458,135 short tons, valued at $113,617,000, based on the average selling price, as compared with 343,418 short tons, valued at $35,029,000, based on the average St. Louis price in 1914—an increase of 114,717 tons, about 33 per cent, in quantity and an increase of $78,588,000, about 225 per cent, in value.

Domestic primary spelter produced in the United States, 1909–1915.

Year.	Quantity (short tons).	Average price at St. Louis.	Value.
1909	230,225	$0.054	$24,864,000
1910	252,479	.054	27,268,000
1911	271,621	.057	30,965,000
1912	323,907	.069	44,699,000
1913	337,252	.056	37,772,000
1914	343,418	.051	35,029,000
1915	458,135	.124	113,617,000

PRICE CURVES, 1914–15.

Plate III shows graphically for the years 1914 and 1915 the relations of the weekly average St. Louis price of spelter, the weekly average London price of spelter, the weekly average price of 60 per cent zinc blende concentrates at Joplin, Mo., and the weekly production, or, to be more exact, the weekly sales of concentrates in the Joplin region as a whole. The price of spelter has been taken from market reports, and the price of zinc blende and the figures of weekly production are those published in the Joplin daily papers. To eliminate the sharp weekly fluctuations and to obtain a curve more easily comparable with the price curves, the weekly sales have been averaged by months, the result being shown by the broken line.

The curve of the London price of spelter for the first seven months of 1914 shows that spelter was about two-fifths of a cent higher in St. Louis than in London. Through this period the price was about at a level. With the outbreak of the war London became the center of the demand for spelter for munitions and the London price became higher than the St. Louis price except for short intervals. The curve is very irregular, with a sharp rise during the early months of the war, culminating in the week ending June 12, 1915, when spelter quotations for ordinary grades averaged above 25 cents. The curve for the last half of 1915 shows rapid and extreme changes in the price of spelter, due to the changing demands and exigencies of the war.

GRADES OF PRIMARY SPELTER.

The American Society for Testing Materials has adopted the following standard specifications for primary or virgin spelter: [1]

Under these specifications virgin spelter—that is, spelter made from ore or similar raw material by a process of reduction and distillation and not produced from reworked metal—is considered in four grades, as follows:

(*a*) High grade; (*b*) intermediate; (*c*) brass special; (*d*) prime western.

Marks: A brand shall be cast in each slab by which the maker and grade can be identified.

Lots: The maker shall use care to have each carload of as uniform a quality as possible.

COMPOSITION.

(*a*) High grade: The spelter must not contain over 0.07 per cent lead, 0.03 per cent iron, 0.05 per cent cadmium. It must be free from aluminum. The sum of the lead, iron, and cadmium must not exceed 0.1 per cent.

(*b*) Intermediate: The metal must not contain over 0.2 per cent lead, 0.03 per cent iron, 0.5 per cent cadmium. It must be free from aluminum. The sum of the lead, iron, and cadmium must not exceed 0.5 per cent.

(*c*) Brass special: The metal must not contain over 0.75 per cent lead, 0.04 per cent iron, 0.75 per cent cadmium. It must be free from aluminum. The sum of the lead, iron, and cadmium must not exceed 1.2 per cent.

(*d*) Prime western: Must not contain over 1.5 per cent lead, 0.08 per cent iron.

Physical: The slabs must be reasonably free from surface corrosion or adhering foreign matter.

Sampling: Not less than 10 slabs shall be taken as a sample from each car; for smaller lots in the same proportion to the total number, but in no case less than 3 slabs. In case of dispute half of the sample is to be taken by the maker and half by the purchaser; the whole to be mixed.

The slabs selected as samples are to be sawed completely across and the sawdust used as a sample. In case no saw is available for this purpose the slabs should be drilled completely through and the drillings cut up into short lengths. The saw or drill used must be thoroughly cleaned. No lubricant shall be used in either sawing or drilling, and the sawdust or drillings must be carefully treated with a magnet to remove any particles of iron derived from the tools.

The specifications for prime western spelter were recently modified as follows: [2]

At a meeting of the board of managers of the New York Metal Exchange, held August 31, 1916, upon recommendation of the spelter committee, the following ruling, defining what constitutes a good delivery on contracts for "Prime Western Spelter," was adopted:

"Prime Western Spelter" shall be virgin spelter resulting from the distillation of zinciferous material and shall not contain on the average in excess of 2 per cent lead and 0.08 per cent iron.

In case of dispute one slab out of every 10 shall constitute a proper sample.

Remelted spelter shall not be a good delivery.

This ruling goes into effect at once, and replaces Rule 1 of the spelter trade rules.

The reason given for this change is that the old idea that prime western spelter should not be over 1½ per cent lead was all right when the metal was made only from Joplin ores, but with the extension of the industry 90 per cent of the prime western spelter produced and marketed has for a long while run over 1½ per cent lead, and therefore the old rule was obsolete and required to be changed to present conditions.

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[1] Metal Industry, July, 1911, p. 301.

[2] The American Metal Market, August 31, 1916.

CANADIAN SPELTER BOUNTY.

In order to encourage the establishment of zinc reduction plants in Canada and to protect the operations from the possibility of disastrous competition after the war, the Canadian Government has established a bounty on spelter made in Canada from Canadian ores.

Bounties on a sliding scale not exceeding 2 cents per pound will be granted upon production in Canada from Canadian ores of zinc containing not more than 2 per cent impurities when the standard price of zinc in London, England, falls below £36 19s. 3d. a long ton (8 cents a pound), provided that bounties shall not be payable on zinc produced before the expiration of the war, or after July 31, 1917, or on zinc contracted for by the shell committee at a price of 8 cents or over per pound. The total amount of bounty to be paid shall not exceed $400.000.

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CADMIUM.

By C. E. Siebenthal.

INTRODUCTION.

A brief account of the production, resources, metallurgy, and uses of cadmium was given as a chapter in Mineral Resources, 1908. A more detailed report is in preparation and will be published as a chapter in Mineral Resources, 1916.

The chief output of cadmium comes from the zinc-producing regions of Silesia, where it is recovered as a by-product in the distillation of zinc. No cadmium is recovered in the United States in the distillation of zinc ores, but most of the output is gained from bag-house dusts at lead smelters which treat lead ores containing more or less zinc. In England a little cadmium is recovered in the purification of the solution of zinc sulphate in the manufacture of lithopone, and some has been recovered in the same way in the United States for several years. Another source of cadmium is the residues left after the manufacture of zinc chloride from low-grade zinc ores and from zinc ashes and drosses. Still other sources which may develop importance are the anode mud resulting from the vats used in the electrolytic refining of spelter and the slimes from the leaching and electrolytic reduction of zinc ores.

PRODUCTION.

Cadmium was first produced in the United States by the Grasselli Chemical Co. in 1907. One by one other companies undertook the recovery of cadmium until there are now four producing companies as follows: American Smelting & Refining Co.; Grasselli Chemical Co.; Krebs Pigment & Chemical Co.; United States Smelting Co.

The following table, compiled from reports by each producer of cadmium in the United States and from official reports of the German Government, shows that the production of cadmium in the United States since 1910 has made rapid gains on that of Germany. Taken together the production of these two countries constitutes practically the whole cadmium production of the world.

Metallic cadmium and cadmium sulphide produced in the United States and Germany, 1907–1915.

Year.	United States.						Germany.		
	Metallic cadmium.			Cadmium sulphide.			Metallic cadmium.		
	Quantity (pounds).	Value.	Average price per pound.	Quantity (pounds).	Value.	Average price per pound.	Quantity (pounds).	Value.	Average price per pound.
1907	14,000	$14,350	$1.025	(a)			72,639	$60,757	$0.84
1908	8,000	6,000	.75	(a)			72,741	48,590	.67
1909	5,300	2,783	.525	(a)			81,982	46,777	.57
1910	4,700	2,585	.55	(a)			90,516	39,309	.43
1911	26,152	17,566	.67	2,392	$1,674	$0.70	93,861	53,372	.57
1912	52,508	39,875	.76	8,998	6,400	.71	94,262	63,507	.67
1913	54,198	41,838	.77	17,302	12,136	.70	81,993	63,641	.78
1914	[b] 91,409	81,205	.89	22,723	20,241	.88	(c)		
1915	91,415	108,443	1.19	10,624	12,057	1.13	(c)		
	347,682	314,645		62,039	52,508				

[a] No production.
[b] Exclusive of 4,225 pounds of cadmium in residues sold for export.
[c] No figures of the cadmium production of Germany later than 1913 are available.

The cadmium output of the United States comes in two forms, as metallic stick cadmium and as the pigment cadmium sulphide, "cadmium-yellow." The domestic production in 1907 was nearly sufficient to supply the home demand—a fact shown by the small imports for that year—but the next year the quantity of cadmium imported was about doubled, and in 1909–1912 the imports of cadmium were back at the old figures which obtained before the beginning of the production of cadmium in the United States. The domestic production has made great strides in the last few years, and as a result the imports of cadmium are naturally growing small. As the imports are largely from Germany they have been practically extinguished for the last two years by the war.

IMPORTS.

Cadmium is imported into the United States as metallic stick cadmium and as the pigment, cadmium sulphide. The former is free of duty; the latter is dutiable at 30 per cent ad valorem. The value of the imports for consumption of metallic cadmium for 1903 to 1913, inclusive, is given in the table below, which is taken from the records of the Bureau of Foreign and Domestic Commerce. The quantities are not there recorded previous to July, 1909, and for the period preceding that time they have been computed by dividing the values of the imports by the average price of cadmium for the corresponding year in Germany, from which country the cadmium was imported. The quantity and value of cadmium imported as a pigment are not kept separately by the Bureau of Foreign and Domestic Commerce.

Cadmium imported and entered for consumption in the United States, 1903–1915.

Year.	Quantity (pounds).	Value.	Year.	Quantity (pounds).	Value.
1903	[a] 8,679	$4,565	1910	4,060	$2,295
1904	[a] 7,655	4,524	1911	5,367	3,870
1905	[a] 8,138	5,298	1912	5,250	3,764
1906	[a] 13,808	10,522	1913	1,656	1,232
1907	[a] 1,953	1,633	1914	441	368
1908	[a] 3,567	2,390	1915	269	284
1909 first half	[a] 6,659	4,559			
1909 second half	2,203				

[a] Prior to July, 1909, the quantities are computed as noted on page 980.

EXPORTS.

Figures of exports of cadmium are not available, but it is known that domestic cadmium is exported. Unrefined cadmium in cadmium residues has also been exported, as noted above.

PRICES.

The price of cadmium throughout the first part of 1915, until the middle of August, was listed in retail lots as nominal at $1.25 to $1.75 a pound. During the remainder of the year the quotations remained at $1.25 to $1.50 a pound. The average price for the year as calculated from sales was $1.19 a pound. The price in London during the first half of the year was from 5s. 6d. ($1.34) to 6s. ($1.46) a pound, and during the greater part of the last half of the year was from 7s. to 7s. 8d. ($1.70–$1.87) a pound.

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U. S. GEOLOGICAL SURVEY

LIST OF DISTRICTS.

ARIZONA.

1. Agua Fria.
2. Ajo.
3. Amole.
4. Banner.
5. Baboquivari.
6. Big Bug.
7. Bunker Hill.
8. California.
9. Cave Creek.
10. Cienega.
11. Cochise.
12. Copper Basin.
13. Dos Cabezas.
14. Ellsworth (Vicksburg).
15. Empire.
16. Globe.
17. Grand Canyon.
18. Francis.
19. Harcuvar.
20. Harshaw.
21. Hassayampa.
22. Helvetia.
23. Hereford.
24. Miami.
25. Mineral Creek (Ray).
26. Metcalf (Greenlee).
27. Morenci (Copper Mountain).
28. Old Hat.
29. Oro Blanco.
30. Palmetto.
31. Patagonia.
32. Pima.
33. Pinto.
34. Pioneer.
35. Planet.
36. Plomosa (Quartzsite).
37. Riverside.
38. Saddle Mountain (Christmas).
39. Silver Bell.
40. Tewiston.
41. Tiger.
42. Tombstone.
43. Turquoise (Courtland).
44. Tyndell.
45. Union Basin.
46. Verde (Jerome).
47. Hualpai.
48. Warren (Bisbee).
49. Wrightson.

CALIFORNIA.

1. Afterthought.
2. Bully Hill.
3. Campo Seco (Valley Springs).
4. Stedman.
5. Copperopolis.
6. Furnace Creek.
7. Iron Mountain.
8. Ben Hur.
9. Little Backbone.
10. Spenceville.
11. Taylorsville.

COLORADO.

1. Alice.
2. Animas.
3. Argentine.
4. Battle Mountain.
5. Blue Mountain.
6. Buckskin.
7. California (Leadville).
8. Carrizozo Creek.
9. Cotopaxi.
10. Douglas Mountain.
11. Eureka.
12. Galena.
13. Gregory.
14. Griffith.
15. Horseshoe.
16. Idaho Springs.
17. Iron Springs (Ophir).
18. Monarch-Garfield.
19. Montana.
20. Mosquito.
21. Nevada.
22. Paradox Valley.
23. Parigo and Union.
24. Pioneer (Rico).
25. Red Mountain.
26. Roaring Fork (Aspen).
27. Rock Creek (Marble).
28. Russell.
29. Sneffels.
30. Sugarloaf.
31. Sunnyside (Creede).
32. Tenmile (Kokomo).
33. Tomichi (White Pine).
34. Turret.
35. Uncompahgre.
36. Upper San Miguel (Telluride).
37. Ward.

IDAHO.

1. Alder Creek.
2. Antelope.
3. Bay Horse.
4. Cottonwood.
5. Dome.
6. Evolution.
7. Hailey (Mineral Hill).
8. Hamilton.
9. Hunter (Mullan, Coeur d'Alene).
10. Lava Creek.
11. Leland.
12. Loon Creek (Castro).
13. McDevitt.
14. Pend Oreille.
15. Placer Center.
16. St. Joe.
17. Seven Devils.
18. Skull Canyon.
19. Texas.
20. Warm Springs.
21. West View.
22. Yreka.

MICHIGAN.

1. Lake Superior.

MISSOURI.

1. Fredericktown.

MONTANA.

1. Amazon.
2. Backer (Diamond).
3. Boulder.
4. Bryant (Hecla).
5. Cataract (Basin).
6. Cedar Plain.
7. Colorado.
8. Divide Creek (Tidal Wave).
9. Elkhorn.
10. Flint Creek (Philipsburg).
11. Georgetown (Cable).
12. Mineral Hill (Pony).
13. Musselshell (Copperopolis).
14. Ophir.
15. South Boulder (Princeton).
16. Spring Gulch.
17. Summit Valley (Butte).
18. Utopia.

NEVADA.

1. Adelaide.
2. Bristol.
3. Bullion (Lander).
4. Contact.
5. Dolly Varden.
6. Eureka (Pinto, Prospect, Ruby Hill).
7. Galena (Copper Basin).
8. Goldfield.
9. Hunter.
10. Newark.
11. Pioche.
12. Robinson (Ely).
13. Santa Fe (Luning).
14. Searchlight.
15. Spruce Mountain.
16. Yellow Pine (Good Springs).
17. Yerington.

NEW HAMPSHIRE.

1. Milan.

NEW MEXICO.

1. Apache.
2. Bromide.
3. Burro Mountain.
4. Central.
5. Cooney (Mogollon).
6. Estey (Oscuro).
7. Eureka (Hachita).
8. Fierro.
9. Highrolls.
10. Hillsboro (Las Animas).
11. Jarilla (Silver Hill).
12. Lordsburg (Pyramid).
13. Magdalena (Kelly).
14. Organ.
15. Pinos Altos.
16. Santa Rita.
17. Scholle-Mountaineer.
18. Tularosa.
19. San Pedro.
20. Twining.

NORTH CAROLINA.

1. Cullowhee.
2. Gold Hill.
3. Virgilina.

OREGON.

1. Quartzburg.
2. Waldo.

PENNSYLVANIA.

1. Cornwall.

TENNESSEE.

1. Ducktown.

UTAH.

1. American Fork.
2. Beaver Lake.
3. Big Cottonwood.
4. Blue Ledge.
5. Boxelder.
6. Detroit.
7. Little Cottonwood.
8. Lucin.
9. Ophir.
10. Rocky.
11. Rush Valley.
12. San Francisco.
13. Snake Creek.
14. Star.
15. Tintic.
16. Uinta (Park City).
17. West Mountain (Bingham.)

VERMONT.

1. Ely.

VIRGINIA.

1. Dumfries.
2. Virgilina.

WASHINGTON.

1. Belcher.
2. Chewelah.
3. Danville.
4. Granite Falls.
5. Index.
6. Meyers Falls.
7. Myers Creek (Chesaw).
8. Palmer Mountain.

WYOMING.

1. Copper Mountain.
2. Douglas Creek (Holmes).
3. Encampment.
4. Platte Canyon (Hartville, Sunrise).
5. Rawhide Buttes.

LIST OF REDUCTION PLANTS.

ARIZONA.

A. Clarkdale. United Verde Copper Co.
B. Clifton. Arizona Copper Co.
C. Clifton. Shannon Copper Co.
D. Corwin. Pioneer Smelter.
E. Douglas. Calumet & Arizona Mining Co.
F. Douglas. Copper Queen Consolidated Mining Co.
G. Globe. Old Dominion Copper Mining & Smelting Co.
H. Hayden. American Smelting & Refining Co.
I. Humboldt. Consolidated Arizona Smelting Co.
J. Miami. International Smelting Co.
K. Morenci. Detroit Copper Mining Co.

CALIFORNIA.

A. Campo Seco. Penn Chemical Co.
B. Coram. First National Copper Co.
C. Kennet. Mammoth Copper Mining Co.
D. Martinez. Mountain Copper Co.
E. Martinez. General Chemical Co. of California.
F. Spenceville. Last Chance and Arkansas Wonder.

COLORADO.

A. Denver. American Smelting & Refining Co.[1]
B. Pueblo. American Smelting & Refining Co.[1]
C. Leadville. American Smelting & Refining Co.[1]
D. Durango. American Smelting & Refining Co.[1]
E. Salida. Ohio & Colorado Smelting & Refining Co.[1]
F. Pueblo. American Smelting & Refining Co.[1]
G. Ouray. Wanakah Mining Co.

[1] Local smelters purchase small lots of copper ores.

IDAHO.

A. Ives. Lost Packer Mining Co.

MARYLAND.

A. Baltimore. Baltimore Copper Smelting & Rolling Co.

MICHIGAN.

A. Hancock. Lake Superior Smelting Co.
B. Hancock. Quincy Smelting Co.
C. Houghton. Michigan Smelting Co.
D. Hubbell. Calumet & Hecla Mining Co.

MONTANA.

A. Anaconda. Anaconda Copper Co. (Washoe plant).
B. Butte. East Butte Copper Mining Co. (Pittsmont plant).
C. Great Falls. Anaconda Copper Co. (Great Falls plant).

NEBRASKA.

A. Omaha. American Smelting & Refining Co.

NEVADA.

A. McGill. Steptoe Valley Mining & Smelting Co.
B. Wabuska. Mason Valley Mines Co.

NEW JERSEY.

A. Bayonne. Orford Copper Co.
B. Chrome. United States Metals Refining Co.
C. Maurer. American Smelting & Refining Co.
D. Newark. Balbach Smelting & Refining Co.
E. Perth Amboy. Raritan Copper Works.

NEW MEXICO.

A. San Pedro. Santa Fe Gold & Copper Co.

NEW YORK.

A. Laurel Hill. Nichols Copper Co.

OREGON.

A. Takilma. Takilma Smelting Co.

PENNSYLVANIA.

A. Natrona. Pennsylvania Salt Manufacturing Co.

TENNESSEE.

A. Copper Hill. Tennessee Copper Co.
B. Isabella. Ducktown Sulphur, Copper & Iron Co. (Ltd.)

TEXAS.

A. El Paso. American Smelting & Refining Co.

UTAH.

A. Garfield. Garfield Smelting Co.
B. Tooele. International Smelting & Refining Co.

VIRGINIA.

A. Dumfries. Cabin Branch Mining Co.
B. West Norfolk. Virginia Smelting Co.

WASHINGTON.

A. Tacoma. Tacoma Smelting Co.

MAP OF THE UNITED STATES

SHOWING LOCATION OF COPPER-PRODUCING DISTRICTS AND REDUCTION PLANTS IN 1915

Scale

1916

THE
STATES

RODUCING DISTRICTS AND OF
NTS IN 1915

LEGEND

- Copper deposits (Numbers refer to list of districts)
- Reduction plant (Letter refers to list of plants)
- Relative output of district (Area of circle represents total output of copper in U. S., 1845 to 1915. Sector represents total output of individual district)